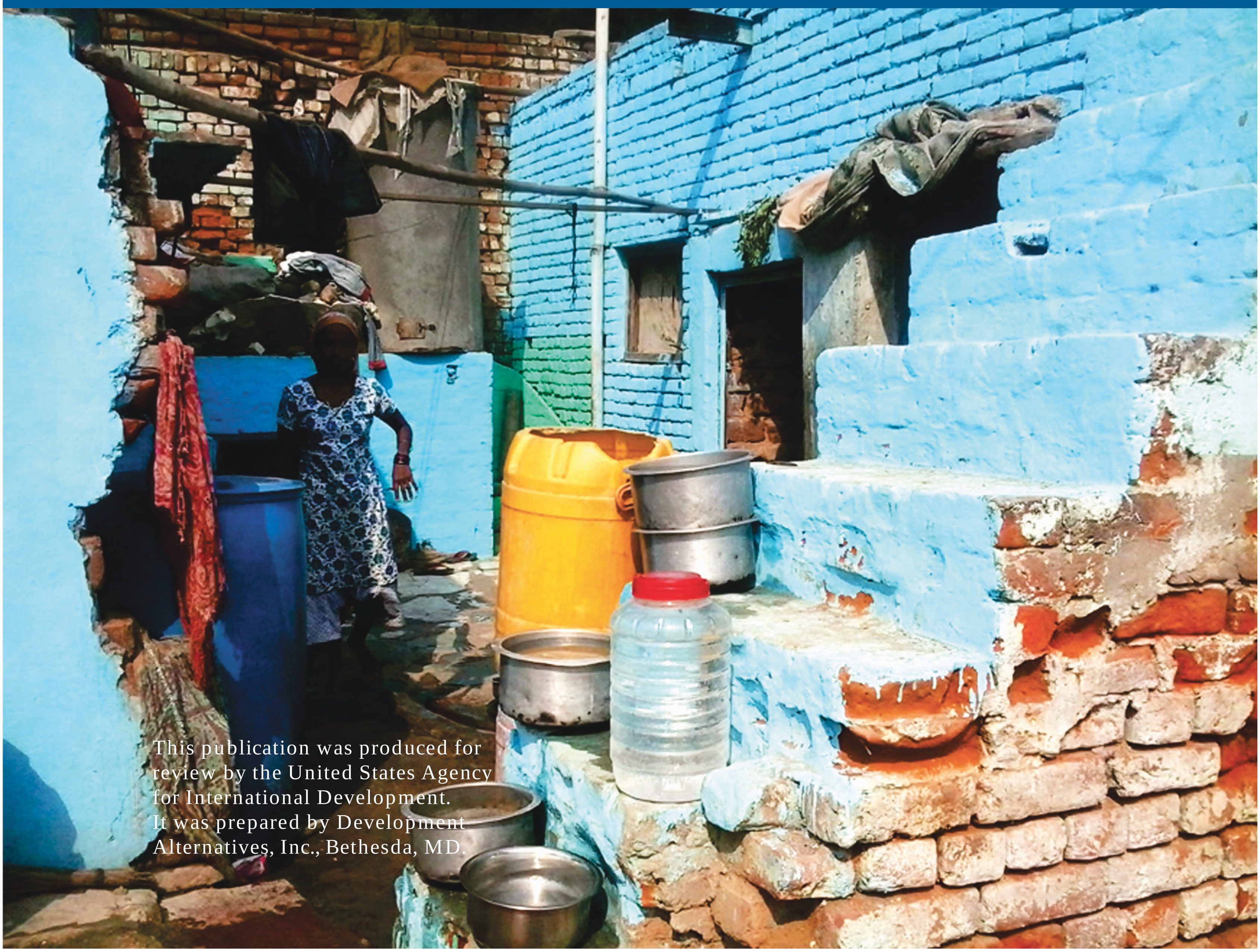
Municipal Water Use Efficiency Guideline Faridabad

Water Analysis, Innovations, and Systems Program

February 2013



This publication was produced for review by the United States Agency for International Development. It was prepared by Development Alternatives, Inc., Bethesda, MD.

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Contract No. AID-EPP-I-00-04-00023

Cover photo: Water stored at the household level in Faridabad. Photograph by AIILSG.

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ABBREVIATIONS AND ACRONYMS

AIILSG	All India Institute of Local Self Government
BMP	Best Management Practices (for water conservation)
CPHEEO	Central Public Health Engineering and Environment Organization
CUWCC	California Urban Water Conservation Council
CGWB	Central Ground Water Board
CII	Confederation of Indian Industries
DAI	Development Alternatives, Inc.
ECBC	Energy Conservation Building Code
FCA	Faridabad Complex Admininstration
GoH	Government of Haryana
GoI	Government of India
gpf	Gallons per flush
gpm	Gallons per minute
GRIHA	Green Rating for Integrated Habitat Assessment
HMCA	Haryana Municipal Corporation Act
HSIDC	Haryana State Industrial Development Corporation
HUDA	Haryana Urban Development Authority
HIG	High income group
IGBC	Indian Green Building Council
IPCC	Intergovernmental Panel on Climate Change
JNNURM	Jawaharlal Nehru National Urban Renewal Mission
LEED	Leadership in Energy and Environmental Design
L/d	Liters per day
Lpcd	Liters per capita per day
LIG	Low income group
MIG	Middle income group
ML	Million liters
MLD	Million liters per day
MCF	Municipal Corporation of Faridabad
NAPCC	National Action Plan on Climate Change
NWM	National Water Mission
NIT	New Industrial Township
NRW	Non-revenue water
NOC	Notified Areas for Control and Regulation of Groundwater
PHED	Public Health Engineering Department
RWH	Rainwater harvesting
SEIAA	State Environmental Impact Assessment Authority
STP	Sewage (Wastewater) Treatment Plant, also known as water pollution control plant (WPCP)
SPS	Sewerage Pumping Station
SEZ	Special Economic Zone
TMCM	Thousand million cubic meters
UV	Ultraviolet
USAID	United States Agency for International Development
WAISP	Water Analysis, Innovations, and Systems Program
WC	Water Closet (also, Bathroom, Restroom, Toilet)
WF	Water Factor (Unit of water use by dishwasher or washing machine per cycle per unit load)

EXECUTIVE SUMMARY

The Water Analysis, Innovations, and Systems Program (WAISP) is a USAID-supported initiative to increase the security of potable water supply and sanitation services by building resiliency to global climate change and advancing sustainable approaches to water management. The program included two components: (1) assessment of the water sector in India in the context of climate change, food security, and health, which was completed in June 2011, and (2) analysis of the potential and feasibility of inter-sectoral water use, primarily providing municipal wastewater for use by industry or industrial clusters in three cities—Faridabad, Jaipur, and Pune. This has been implemented by Development Alternatives, Inc. (DAI), with support from The Communities Group International, and the All India Institute of Local Self Government (AIILSG). In addition, the Confederation of Indian Industry's (CII) Triveni Water Institute is working in parallel with USAID to conduct water audits and carry the initiative forward.

The second component has included several elements, and this report consolidates all of the activities and analysis completed related to Faridabad:

1. Review of the water supply and sanitation infrastructure serving the city, as well as a desk analysis of the potential climate change impacts on Faridabad and the threats they pose to water resources in the short and long term.
2. Analysis of the legal framework related to water resources.
3. Summary presentation of primary survey research of the principal non-industrial water users in the city, totaling 494 sampling units.
4. Presentation of opportunities and recommendations to improve urban water use efficiency, including specific projects for consideration by officials and water users in Faridabad.
5. Compendium of selected national and international best practice case studies and references to engage stakeholders in considering the merits of various successful models.

Water scarcity is a looming threat to orderly development and growth of India's major cities, in similar fashion to most of the semi-arid and arid regions of the world. A fast growing population and increasing standards of living will combine with the effects of global climate change to exacerbate this scarcity.

National and Local Context

Water scarcity is a looming threat to orderly development and growth of India's major cities, in similar fashion to most of the semi-arid and arid regions of the world. A fast growing population and improving standard of living will combine with the effects of global climate change to exacerbate this scarcity. Fortunately, much can be accomplished to increase the efficiency of water use in India's cities in a relatively short period of time. The reason for this optimism is twofold: (a) current water use efficiency is at a very low level, and (b) international experience and advanced technology can offer proven solutions to maximize the benefits of available water supplies in the most equitable manner possible.

The Twelfth Five Year Plan (2012-2017) released by the Planning Commission, Government of India (GoI) has analyzed in detail the water situation in general and in the specific context of industries. The Plan document quotes estimates of the “2030 Water Resources Group” which indicates that if current patterns continue, about half of the water demand will be unmet by 2030, and therefore recommends a reform agenda and paradigm shift to address the challenge. This shift includes “definite targets for recycling and reuse of water by Indian industry to move in conformity with international standards” (GoI, 2012d).

The Plan document quotes estimates of the “2030 Water Resources Group” which indicates that if current patterns continue, about half of the water demand will be unmet by 2030, and therefore recommends a reform agenda and paradigm shift to address the challenge.

Given this backdrop, WAISP conducted a series of consultative meetings with USAID, CII's Triveni Water Institute, and officials within various municipalities. The guiding principles for selecting Faridabad, Jaipur, and Pune were: (1) water scarcity with high potential for growth; (2) feasible within a one year time frame; (3) enables donors and the municipalities to follow-up with longer-term initiatives based on the results; (4) interest of municipal authorities to focus on the interface across the urban built environment and industry; (5) linkages with CII's networks for follow-up.

For its part, Faridabad depends both on the Yamuna River and on groundwater for its water supply. Mapping of water stress in 2012 suggests that Faridabad is in a region of “extreme risk”, which means that the total water use is significantly greater than the renewable water available to the city. This study deduces the probability of occurrence of four climate change events in the region for the A1B scenario of emissions as defined by the Inter-governmental Panel on Climate Change, and assesses the likely impact of these events on Faridabad city based on secondary data.

Considering that the flow of the Yamuna River and canal flowing through Faridabad city is regulated through dams upstream, it is expected that the vulnerability of the city to greater glacier melt from the Yamunotri glacier in the short term is low, although the likelihood of floods in northern India is high as a result of climate change. Faridabad falls in the critical category with groundwater development in excess of 90%; some 36% of the groundwater recharge is estimated from monsoon rainfall.

Although there is no established evidence of aquifers being contaminated, there are reports of an increase in salinity because of over-extraction, and apprehensions regarding more serious problems such as occurrence of arsenic in groundwater. Faridabad is categorized as chronically drought-affected by the Ministry of Agriculture. The Disaster Management Plan for MCF suggests that the impact of drought is likely to be moderate; but an increasing gap in demand

and supply in the next 30 years is likely to enhance the vulnerability of the city to drought. At the same time, the impact of floods on the city has been assessed as "high" because: a) inadequate storm water drainage; and b) forecasts of increased rainfall in northern India in climate change models.

Vulnerability due to reduced recharge is assessed as "medium" in the short term, but significant in the longer term (2050s). The response plan of the city to these threats, particularly to restrict further depletion of groundwater, is commendable. However, there is a strong need to reinforce water stewardship by increasing wastewater reuse, reducing wastage and losses, and promoting water use optimization.

Water Use

A primary quantitative survey was designed to supplement the secondary data and qualitative information collected. The survey assessed the pattern of water use within the city area across different segments of water users, including domestic and commercial (but not industrial). While it had a limited scope, the survey yielded valuable reinforcing information that, when taken in concert with other data sources, studies, and priorities, suggest trends which may be helpful for decision-makers interested in identifying opportunities for water use optimization.

The focus of the survey was on domestic water use, and therefore 294 households from residential clusters from different geographic areas of the city—Ballabgarh town, Old Faridabad Township, Faridabad N.I.T. Township, and new urban developments build over the last 10 years. The survey also covered 62 schools, colleges and other educational institutes, 19 hotels and guest houses, 10 restaurants, 30 hospitals/health care establishments, 31 temples/religious institutions, 10 government offices, five public gardens, 20 vehicle service stations, and 13 other commercial establishments.

A little more than a quarter of the households surveyed (27%) belong to the high income group (HIG), more than half (58%) belong to middle income group (MIG), while one-seventh (15%) are low income (LIG). Some 73% of the households reported having access to municipal water supply, and they depend exclusively on this source, while 12% rely exclusively on their own sources. The extent of metering is very low in Faridabad. Among those surveyed, only 32% of those with municipal water supply have meters, of which 73% functioned. Very few households (6%) use dual flush toilets. Nearly three-fourths (73%) of the households surveyed reported using washing machines; 82% of these were front-loading machines, which generally require more water during a normal washing

Some 73% of the households reported having access to municipal water supply, and they depend exclusively on this source, while 12% rely exclusively on their own sources. The extent of metering is very low in Faridabad. Among those surveyed, only 32% of those with municipal water supply have meters, of which 73% functioned.

cycle. Rainwater harvesting (RWH) systems have been installed by only 6% of surveyed households, mostly by those within the HIG category. Nearly 40% of the residences surveyed cultivate a home garden, and virtually all of them water with a hand held hose or bucket.

Institutions and commercial establishments surveyed actually demonstrated similar trends, with most depending entirely on municipal water supplies, and very few demonstrating water conservation techniques. Three quarters of schools surveyed have single flush toilets and none have efficient dual flush models. While two hotels surveyed irrigate their landscaping with harvested rainwater, and four of the service stations surveyed re-circulate wastewater from car washes, these practices were in the minority.

Faridabad city is unique among the other cities in Haryana state because, unlike in other cities, the responsibility for providing drinking water lies with the Municipal Corporation of Faridabad (MCF) and not the Public Health Engineering Department (PHED)... Responsibility for water supply in Faridabad is also shared by MCF with Haryana Urban Development Authority (HUDA), Haryana Housing Board and Haryana State Industrial Development Corporation (HSIDC).

Legal Framework

Faridabad city is unique among the other cities in Haryana state because, unlike in other cities, the responsibility for providing drinking water lies with the Municipal Corporation of Faridabad (MCF) and not the Public Health Engineering Department (PHED). Faridabad also falls within the Central National Capital Region, and therefore the National Capital Region Planning Board Act, 1985, which established the National Capital Region Planning Board (NCRPB) in the Ministry of Urban Development, Government of India, is applicable to the whole of the District of Faridabad. Responsibility for water supply in Faridabad is also shared by MCF with Haryana Urban Development Authority (HUDA), Haryana Housing Board and Haryana State Industrial Development Corporation (HSIDC).

Haryana state has announced several policy initiatives during the last 10 years or so to conserve water, especially by harvesting rainwater. The most recent are the Draft State Water Policy (2011) and the Haryana State Urban Water Policy (2012). Earlier, the Haryana Urban Development Authority (Erection of Buildings) Regulations (1979) were amended in 2001 making RWH mandatory for all buildings with roof area of 100 m^2. An identical provision was made in 2002 in the Haryana Municipal Building By-Laws, 1982, without which occupation certificate is not supposed to be issued. Section 23 of the Haryana State Groundwater Management and Regulation Bill (2008), which is at a draft stage, would require local authorities to impose conditions for rainwater harvesting for buildings plans with over 500 m^2 of rooftop area. The Punjab Scheduled Roads and Controlled Areas Restriction of Unregulated Development Rules, 1965 were amended in 2007 to insert a provision for rainwater harvesting. A memo issued by the Town and Country Planning Department in 2006 requires builders to make arrangements for RWH. MCF has also reportedly amended its building by-laws to make RWH mandatory in all new buildings with roof area of 100 m^2 or more. Treatment, recycling and reuse of wastewater have been proposed in Haryana State Groundwater Management and Regulation Bill, 2008 and more recently by the Irrigation Department. The Action Plan for Abatement of Pollution in Faridabad by the state Pollution Control Board contains the same proposal. The Industrial and Investment Policy (2011) makes similar declarations for the industrial sector. Haryana State Urban Water Policy (2012) prescribes mandatory metering as one of the measures for more efficient water use.

However, the findings from the household survey suggest that, at present, there is very little real action to conserve water or to achieve efficiency in water use in the domestic sector in Faridabad city.

Opportunities

Although there are several legal and policy directives in favor of water conservation and reuse, our survey shows very little effort in this regard across the key categories of users questioned. There are isolated instances of water reuse in the city, such as with the Aravali Golf Club in Faridabad, a property owned by Haryana Tourism Corporation, which has installed a sewage treatment plant (STP) which processes 100,000 liters of waste water per day from the neighboring area and reuses it for watering the fairway. This accounts for approximately one-third of its total water requirement. Similarly, SRS Developers, one of the large realtors in the city are adopting dual plumbing for reuse of gray water and other water-efficient technologies in their projects.

... the fabric dyeing and garment industry in Faridabad also use around 5.5 million liters of water daily; the discharge from these units can be treated by installing combined sewage treatment plants and reusing the water for agricultural irrigation or other uses.

The opportunities for increasing water use efficiency include discussions about technologies, behavior change, legal reforms, with these contextualized in some specific project opportunities. In addition, a special consideration for Faridabad is the poor fiscal health of the city. Incentive and penalty schemes must be designed with this in mind, and therefore, the city should consider innovative public-private partnership schemes, and put emphasis on approaches that otherwise generate revenue. For example, imposing fines on wasteful water use practices, or new taxes on inefficient fixtures and appliances.

One project that can be considered is establishing root zone treatment systems for treating wastewater in the large public gardens for irrigation reuse, and expanding recycled water use for irrigating the golf course. Operation and maintenance can be outsourced to private providers. There is scope to introduce efficient ways of washing buses in the Ballabgarh bus depot. Technologies can remove grease and dirt from water used for washing buses in order to enable water reuse. In addition, the fabric dyeing and garment industry in Faridabad also use around 5.5 million liters of water daily; the discharge from these units can be treated by installing combined sewage treatment plants and reusing the water for agricultural irrigation or other uses. In addition, legal tools and economic instruments can encourage improved water use efficiency. Labeling water fixtures with flow rates can facilitate consumer choice and promote water demand management.

Conclusion

Faridabad faces special challenges given its geographic location and status within the National Capital Region, as well as state of Haryana. It is too dependent on overdrawn water resources and does not presently meet estimated water demand levels. This makes the city vulnerable to supply shortfalls expected due to climate change. Particularly in the long-term, the potential for the city to experience scanty rainfall and more intense weather events is high. Faridabad is already experiencing economic pressures, and businesses are finding it less attractive to locate here, sometimes due to inadequate water supplies. This only further erodes the tax base for the city, and reduces the potential for investment in municipal services, including water and wastewater. It is therefore quite urgent to reverse this trend. In the water sector, this requires balancing changes that will improve service delivery and increase tariffs to levels that at least cover operating and maintenance costs. Adopting water use efficiency approaches, including water reuse, will further reduce the cost burden for water supply and wastewater treatment, and so form an integral part of the city's effort to achieve fiscal health.

I. INTRODUCTION

The Water Analysis, Innovations, and Systems Program (WAISP) is funded by the U.S. Agency for International Development (USAID/India). The overall goal of the program is to increase the security of potable water supply and sanitation services by building resiliency to global climate change and advancing sustainable approaches to multiple use water services provision for potable and productive applications.

WAISP began by conducting a water sector assessment of eight states in India, which looked specifically at water vulnerability in relation to climate change, food security, and health (available as separate report completed June 2011). The program then carried out three city-level analyses for ways to improve water efficiency in representative cities—Faridabad, Jaipur, and Pune—which were identified as having potential for national replication.

For USAID/India, the inter-linkages between water resources and climate change, food security, and health are of paramount importance. India faces multiple challenges relating to competing uses of scarce water resources—between household and municipal consumption, agriculture, industrial, and ecosystem services. Furthermore, projected impacts of climate change indicate a higher variability in precipitation, with more frequent droughts and floods, and general stress on the hydrologic regime. Unrestricted groundwater exploitation by all sectors in the absence of adequate regulation and pricing is already severely impacting water scarce areas.

For the second program component, WAISP conducted a series of consultative meetings with USAID, the Confederation of Indian Industry's (CII) Triveni Water Institute, and officials within various municipalities. The guiding principles for selecting Faridabad, Jaipur, and Pune were: (1) water scarcity with high potential for growth; (2) feasible within a one-year time frame; (3) enables donors and the municipalities to follow-up with longer-term initiatives based on the results; (4) interest of municipal authorities to focus on the interface across the urban built environment and industry; (5) linkages with CII's networks for follow-up.

The results of WAISP's second component are presented in three separate reports, one for each city—Faridabad, Jaipur, and Pune—as a *Guideline for Water Use Efficiency*. This document represents the Guideline for Faridabad and includes a city profile and background, review of the water supply and sanitation infrastructure, as well as their vulnerabilities to potential climate change impacts, analysis of the legal and policy framework related to water, as well as survey results on water use trends in the city. The report concludes with a review of recommended opportunities to improve urban water use efficiency, and reference

...the Government of India's Approach Paper for the 12th Five Year Plan (2011) observed "It is necessary to match our use, through improvement in efficiency, with the annual replenishable water supply that the country receives. Available evidence suggests that with increased use of water, mostly on an unsustainable basis, the country is headed towards a grave water crisis" (GoI, 2011b).

compendium of relevant Indian and international case studies. This Guideline is designed to serve as a decision-support resource for municipal officials to better understand and address the existing and looming water resource constraints in Faridabad.

National Context

Water is a "State" subject in the Indian Constitution, which means that states are free to pursue their own policies regarding its use, and have exclusive power to legislate on this subject.[1] The central government provides funds to states from its budget to improve water resource management and has an advisory role in this sector, which flows from the issuance of guidelines. The Draft National Water Policy of June 2012 states: "Even while it is recognized that States have the right to frame suitable policies, laws and regulations on water, there is a felt need to evolve a broad over-arching national legal framework of general principles on water to lead the way for essential legislation on water governance in every State of the Union and devolution of necessary authority to the lower tiers of government to deal with the local water situation" (GoI, 2012a).

Previously, the Government of India's Approach Paper for the 12th Five Year Plan (2011) observed "It is necessary to match our use, through improvement in efficiency, with the annual replenishable water supply that the country receives. Available evidence suggests that with increased use of water, mostly on an unsustainable basis, the country is headed towards a grave water crisis" (GoI, 2011b). The Approach Paper commented "…the real solution has to come from greater efficiency in water use." It also emphasizes the need to establish a National Water Commission (NWC) to monitor compliance with the national water strategy.

Following this approach, the Twelfth Five Year Plan (2012-2017) released by the Planning Commission, Government of India (GoI) has analyzed the water situation generally, and in the specific context of industry. The Plan document quotes estimates of the "2030 Water Resources Group" which indicates that if current demand patterns continue, about half of the demand for water will be unmet by 2030, and therefore recommends a paradigm shift and reform agenda to address the challenge. This shift includes "definite targets for recycling and reuse of water by Indian industry to move in conformity with international standards" (GoI, 2012d).

[1] However, the national Parliament has the power to legislate the regulation and development of interstate rivers.

Recycling wastewater for industrial use has been advocated as it not only helps in conserving fresh water, but also reduces the quantum of untreated wastewater discharged to common water bodies, which causes environmental degradation and compounds the disease burden. Nationally, over 70 percent of municipal wastewater is discharged untreated into rivers and waterways, with severe health implications from biological contamination. Also, while the Environmental Protection Act of 1986 mandates that all industrial effluents be treated prior to disposal, statistics indicate that toxic effluents to the tune of 40 percent go untreated into mainstream water bodies, causing chemical contamination with risks to human health, environment, and agriculture.

The agenda for reforms in the 12th Plan will have four thrust areas:

- Agenda 1: Focus on demand management, reducing intra-city inequity and on quality of water supplied
- Agenda 2: Protection of water bodies
- Agenda 3: Water supply scheme conjoined with a sewage component
- Agenda 4: Recycling and reuse of treated wastewater

Additionally, the Plan document acknowledges the need for industries to adopt international best practices to improve water use efficiency. It suggests two ways in which this can happen:

- Reducing the consumption of fresh water through alternative water efficient technologies or processes in various manufacturing activities; and
- Reusing and recycling wastewater from water intensive activities, and making the reclaimed water available for use in the secondary activities.

A recent Advisory Note from the Ministry of Urban Development recognizes the threat to both quantity and quality of water resources in the country resulting from rapid urbanization and underscores the need to collect and treat wastewater, which would contribute to managing the finite resource more effectively. The note highlights two key emerging challenges in the water sector: first, to ensure environmental and financial sustainability; and second, to ensure equitable service provision, especially to the urban poor. The following recommendations from the Working Group on Urban Water Supply and Sanitation for the 12th Plan cited in the Note are significant (GoI, 2012c):

A recent Advisory Note from the Ministry of Urban Development recognizes the threat to both quantity and quality of water resources in the country resulting from rapid urbanization and underscores the need to collect and treat wastewater, which would contribute to managing the finite resource more effectively.

The Ministry of Water Resources is also taking steps to establish the National Bureau of Water Use Efficiency... Some of the approaches under consideration include scaling up water recycling, artificial groundwater recharge, and enlarging the scope of activities for treated wastewater reuse.

- Careful assessment of the total cost of the water and sewage sector is required to ensure that projects are planned in an affordable and sustainable manner.

- Water and sewage services must be paid for in order to recover costs.

- Future investments in water supply should include elements of demand management (reducing water usage) and distribution system leakage management to help reduce intra-city inequities in both quantity and quality of water supplied.

- Building, renewing, and replenishing local water resources, including groundwater, to cut costs of water supply through investments in sewerage and in increased reuse and recycling of wastewaters.

- Building capacities at all levels, including exploring institutional and management options for improved water and sanitation provision in cities.

The broad objectives of conserving water, minimizing wastage in use, and ensuring more equitable distribution are also reiterated in the Mission statement of the National Water Mission (NWM) —one of the eight Missions created as part of the National Action Plan to address Climate Change (NAPCC). The NWM intends to achieve this objective through integrated water resources development and management.

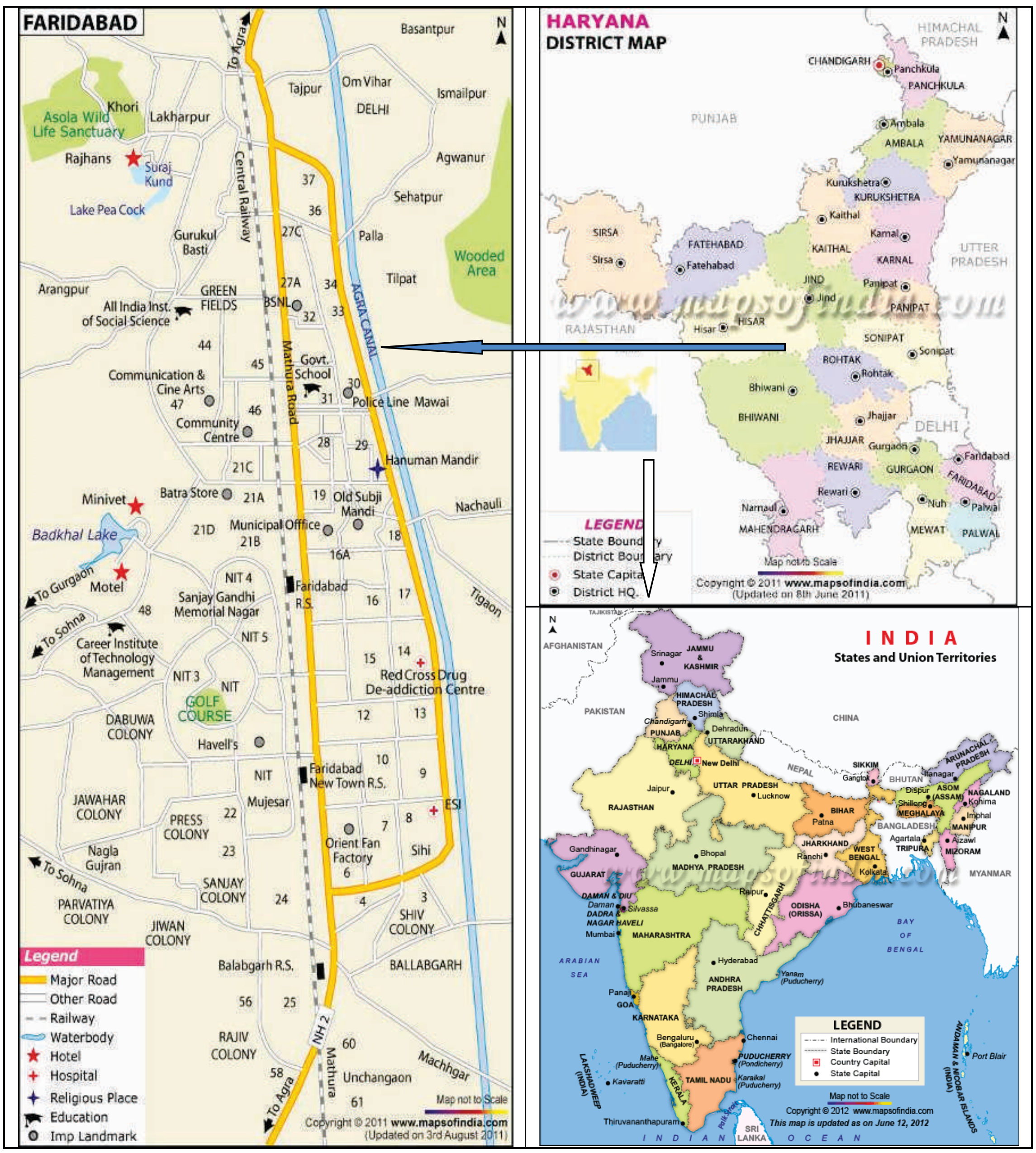
The Ministry of Water Resources is also taking steps to establish the National Bureau of Water Use Efficiency. When established, the Bureau will work to reduce distribution losses (non-revenue water) in domestic utilities. The Bureau will also seek to demonstrate approaches to achieve 20% water use efficiency improvements across water uses (domestic, industrial, commercial, irrigation), and will offer incentives to achieve this level of water savings. Some of the approaches under consideration include scaling up water recycling, artificial groundwater recharge, and enlarging the scope of activities for treated wastewater reuse.

In the following sections, the characteristics of Faridabad city, vulnerability to the effects of climate change, hydrology, current water and sewerage conditions, water use practices, and opportunities for water conservation are presented. Recommendations for specific opportunities deserving further attention and analysis, and best management practices are offered as part of this project, based upon on-site observations, discussions with water authorities, and the results of a water use survey conducted.

Faridabad City Profile

Faridabad is a city in the southeastern part of Haryana state, 32 km from Delhi founded in 1607 AD. The city is bounded on the north by the Delhi territory, on the east by Agra and the Gurgaon canals, and on the west by the Aravali Hills. The Yamuna River flows very near the city along its northern side and moves away as it travels south.

Figure 1: Map of Faridabad City and its Location in India



Source: www.mapsofindia.com

Municipal Corporation of Faridabad (MCF) and Haryana Urban Development Authority (HUDA) are the primary institutions responsible for urban development and municipal service delivery in Faridabad. All core municipal services, including their design and implementation, are within the domain of MCF, while HUDA primarily exercises the role of a land developer...

Prior to its inception as a Corporation in 1993-94, the present-day Municipal Corporation of Faridabad (MCF) was referred to as the Faridabad Complex Administration (FCA), comprising the municipalities of Faridabad Township, Old Faridabad, Ballabgarh and 38 revenue villages. The present Municipal area of Faridabad is 207.88 km^2, and has remained constant since the establishment of Faridabad Municipal Corporation in 1992. Of this area, 156.79 km^2 is urbanized, as noted in Table 1.

The Municipal Corporation of Faridabad (MCF) and Haryana Urban Development Authority (HUDA) are the primary institutions responsible for urban development and municipal service delivery in Faridabad. All core municipal services, including their design and implementation, are within the domain of MCF, while HUDA primarily exercises the role of a land developer; its main functions include, to:

- Promote and secure development of urban areas with the power to acquire, sell and dispose of property, both movable and immovable.
- Acquire, develop, and dispose land for residential, industrial and commercial purposes.
- Make available developed land to Haryana Housing Board and other bodies for providing houses to economically weaker sections of the society.
- Undertake building works.

Faridabad is divided into 107 sectors; 89 come under the MCF, while HUDA administers the remaining 18 sectors. It may be noted that HUDA, apart from providing basic infrastructure like roads, drains and street lights in developing a sector, also maintains the area for five years. If such sectors fall under the jurisdiction of MCF, assets are later transferred to MCF for maintenance. However, water supply, sewerage, and waste management functions are the responsibility of MCF from inception, irrespective of whether it is administered by MCF or not. Some view this as causing a substantial revenue loss for MCF, since it can only collect taxes on properties it administers.

To an extent, the Town and Country Planning Department of the Government of Haryana also has an institutional role in preparing the Development Plan (DP) for the city area as well. It prepares the DP for all urban areas in the city, taking into consideration the needs of industrial, residential, and commercial sectors. However, the implementation of the plan is not the domain of the department.

Agencies such as HUDA and MCF, etc. implement the DP after acquiring the land and preparing detailed schemes in line with the proposals of the DP.

Growth Trends

Just about half of the land area in Faridabad city is used for residential purposes. Industries occupy the next highest proportion (20%), while roads and transport use nearly 10% of the space. Commercial uses like shops and other establishments occupy 5% of the land. Table 1 provides the details of land use by category.

Table 1: Land Use in Faridabad City Area

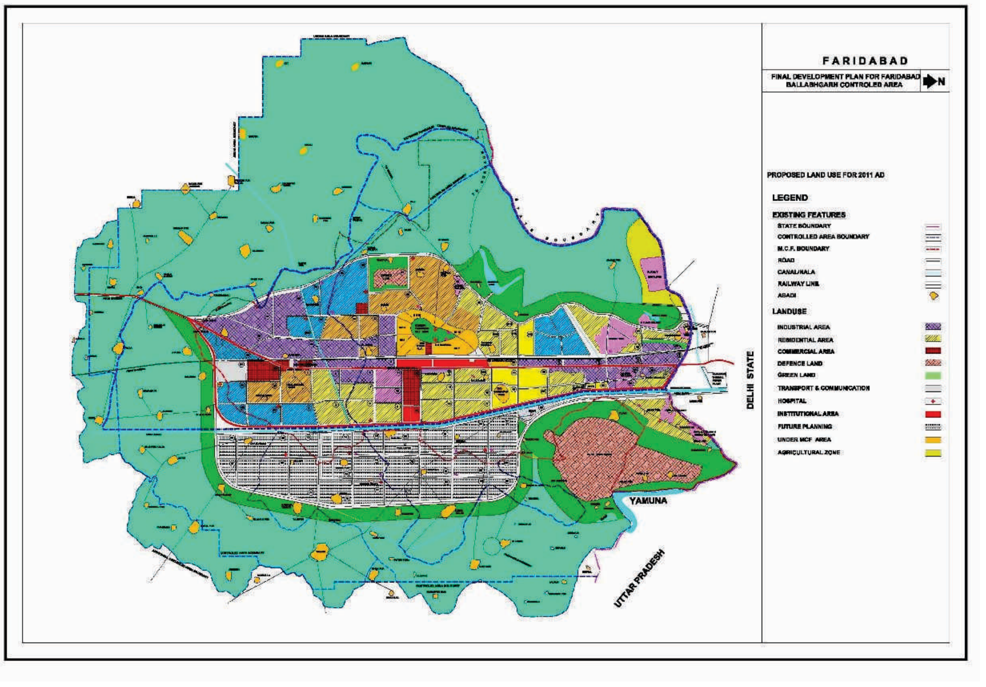
Land Use	Area (km^2)	Percentage
Residential	77.95	49.7%
Commercial	7.73	4.9%
Industrial	31.36	20.0%
Special zone	4.42	2.8%
Public utilities	1.55	1.0%
Public & semi-public	5.30	3.4%
Transportation/ circulation	15.54	9.9%
Open spaces/ recreation	12.95	8.3%
Total	**156.79**	**100.0%**

Source: City Development Plan, Faridabad, 2006-2012: Prepared by CRISIL for MCF

Faridabad is an important part of the National Capital Region (NCR) and is identified as a Central National Capital Region (CNCR) city. While being part of CNCR presumably extends a kind of priority status to the city, the state of infrastructure disrepair reflects a different reality. The quality of infrastructure within the NCR Territory shows huge disparities. The governance and poor financial condition of the Municipal Corporation of Faridabad also reflects this disparity.

After India's independence, Faridabad became one of the centers for the resettlement of displaced persons from Pakistan. In 1979, Gurgaon—a new district—was carved out of Faridabad district, and Faridabad city became the headquarters of this new district. In the 1950s, soon after partition, some industrial activity began as part of the Pakistani Refugee Resettlement Project. The industrial infrastructure in and around the city was laid by the new migrants. Faridabad gradually emerged as a major industrial hub of India, with hundreds of large industries and several thousand small scale industries. The city generates 60% of the revenue for Haryana state and fully half of all state income tax is collected from two cities—Faridabad and Gurgaon.

Figure 2: Land Use Perspective Plan 2011



On the whole, the total number of small, medium and large industries in the Faridabad-Ballabgarh Complex add up to about 15,000. This industrial estate in Faridabad is spread over an approximate area of 6,948 hectares, and is home to a variety of engineering products. Tractors, steel re-rolling, scientific instruments, power looms, and agricultural implements represent the major industrial production in the district. The industrial complex provides direct and indirect employment to nearly half a million people, and ranks as the 9th largest industrial estate in Asia. Its combined turnover is estimated to be about Rs.1,500 billion. It houses many multinational companies like Whirlpool, Goodyear, Larsen & Toubro, Asea Brown Boveri, GKN Invel, Woodward Governor and Castrol, besides major Indian corporate firms like Escorts, Eicher, Cutler Hammer, Hyderabad Asbestos, and Nuchem, etc.

The industries of Faridabad employ both skilled and unskilled workers. The majority of the workforce today is in the service sector. Migration within NCR is low, but migration into NCR from other regions of Northern India is high given the relatively better employment opportunities. This migration puts great pressure on basic municipal services, especially drinking water and sanitation.

2. WATER SUPPLY AND CLIMATE CHANGE VULNERABILITY

Hydrologic Setting

Faridabad city experiences a semi-arid climate characterized by wide temperature variations and scanty and irregular rainfall. During summer, temperatures may reach 45 degrees Celsius in June, while in winter it can drop to as low as 2 degree Celsius in December. May and June are the hottest and driest months, when dust storms from the west occur. The average annual rainfall recorded at the Faridabad rain gauge station is 845 mm (CGWB, 2007), based on data from 1978 to 1997. Maximum rainfall occurs during July to September during the southeast monsoon. The number of actual rainy days varies between 7 and 22 per year.

A major part of Faridabad city is underlain by quaternary alluvium, consisting of sand, clay and silt. In the western and northwestern part of the town, the quartzite ridges of the Delhi system can be observed. Along the Yamuna flood plain toward the eastern part of the town, the younger alluvium is mainly sandy, with a thickness of about 10-15 m. The main aquifers consisting of a sandy layer are generally confined to 60m below ground level. Beyond this depth the alluvium is more clay-like, and generally lacks the capacity to carry aquifers even though the depth of bedrock is more than 200m. The limited thickness of aquifers further restricts the development of groundwater on a larger scale. In the Delhi quartzites, the availability of groundwater is also limited and is controlled by secondary permeability imparted by joints and fractures.

Water Supply and Delivery Infrastructure

For its water supply, Faridabad relies on groundwater from 420 deep tube wells located in various parts of the city, plus two ranney wells located along the Yamuna River. The Yamuna originates at the Yamunotri glacier in the Lower Himalayas. The total installed capacity of the tube wells is 195 million liters per day (MLD), with another 45 MLD available from the two ranney wells, resulting in a total installed capacity of 240 MLD.

Tube wells are drilled to a depth of between 200-350 feet, and the discharge from tube wells varies from 2,500 to 15,000 gallons per hour. The discharge from the tube wells located closer to the canal is higher in comparison to the rest. The spring level, which during the early 1970s was 15-20 feet below ground level, is now in the range of 45-60 feet below ground. This level falls more steeply toward the farther end on western side of the canals toward the Aravali Hills. It is therefore essential to better manage water demand, curb network losses, and evaluate alternative reliable water sources to continue serving the present per capita supply and keep pace with the increasing population.

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Three-quarters of water demand comes from domestic users, either household connections or through stand posts. In spite of the large scale industrial activity in and around the city, and the huge contribution that this sector makes to the economy of the city and the region, industries officially account for only 5% of total water demand.

The Municipal Corporation of Faridabad (MCF) has proposed a desired level of per capita supply at 135 liters per capita/day (Lpcd) considering the large industrial demand in Faridabad, and its estimated growth to 2031. The City Development Plan further estimates demand to be in the range of 896 MLD in 2031 against the current supply of 240 MLD. The population of Faridabad as per the 2011 census was 1,798,954, up by almost 70% from 2001, and more than the projected values in the City Development Plan formulated in 2006 (MCF 2006). Considering the trend, the estimated demand in 2031 will be greater than 896 MLD and even higher in the longer term.

Three-quarters of water demand comes from domestic users, either household connections or through stand posts. In spite of the large scale industrial activity in and around the city, and the huge contribution that this sector makes to the economy of the city and the region, industries officially account for only 5% of total water demand. Discussions with MCF officials, however, suggest that this figure does not tell the whole story. The actual demand from the industrial sector is much higher. Industries are reported to be building their own groundwater sources to meet their needs, as well as purchasing water from private suppliers through tankers. Besides, several industries like the East India Cotton Mills, Escorts, Bhaskar Stoneware pipes, etc. have shifted their manufacturing facilities elsewhere because water supplied from the MCF supply system to industries has been insufficient; domestic water requirements have always been a higher priority. Table 2 below shows the water demand by sector in Faridabad.

Table 2: Demand for Water by Sector in Faridabad City

Types of use	Demand MLD	Share %
Domestic connections	266	68.7
Public stand posts	30	7.8
Industrial	20	5.2
Commercial	10	2.6
Institutional	34	8.8
Parks	27	6.9
Total	**387**	**100.0**

At present, raw water is transmitted from the tube wells and the ranney wells to various underground reservoirs through rising mains and transmission mains, which run a total length of 40.39 km before pumping into the Elevated Service Reservoirs (ESR) for further distribution. There are 22 Ground Level Storage Reservoirs (GLSR) fitted with boosting stations. The total capacity of the GLSRs is 54.55 million liters (ML), representing 23% of the installed capacity of the water supply system. The Faridabad distribution system is based on the division of the entire city into three primary zones—Old Faridabad, Ballabgarh, and NIT. These zones are sub-divided into various sectors or colonies for further distribution, each one served by an elevated service reservoir of 1 lakh gallons (4.55 ML) capacity.

In all, the city has 25 ESRs with a total capacity of 11.37 ML, representing nearly 5 % of the installed water supply capacity of 240 MLD. Ideally, however, it is necessary to have one-third of the installed capacity as elevated storage for intermittent supply systems; Faridabad falls short of this standard. It is further notable that the groundwater being extracted at present is only disinfected with chlorine prior to distribution, since high salinity is the only problem detected in groundwater.

The total length of the distribution system in Faridabad is 910 km. against the available road length of about 1,218 km. The distribution network covers 75% of the road length, suggesting a fair coverage of the city. However, the total number of household service connections in the city is 146,646, covering only 65% of the total properties assessed. An estimated 20% of the population has no municipal service coverage. As per MCF reports, of those served, just over half have metered connections (52%). Water is supplied for three to four hours every day. Currently, the total number of public stand posts (PSP) provided by various agencies including MCF, Public Health Engineering Department (PHED), and HUDA is about 765, of which an estimated 425 are located in various slums of the city.

MCF has partially privatized the operation and maintenance of all the tube wells supplying water to the city. At present, maintenance of 400 tube wells—roughly 40% of the total—has been outsourced to a single private operator, which has established a centralized monitoring system with control over the hours of operation of the tube wells.

With respect to tariffs, the structure has been fixed by the Government of Haryana (GoH) across the state irrespective of the cost of service, as in most cities in India. Tariffs are charged at different rates for metered and unmetered connections. Table 3 summarizes the tariff for unmetered domestic connections.

Table 3: Water Tariffs for Unmetered Domestic Connections

No. of fausets	Ferrule size	Flat rate Rupees/month
1	1 to 10 mm	25
More than 1	1 to 10 mm	60
Any number	11 to 15 mm	120
Any number	16 to 20 mm	180
Any number	more than 20 mm	240

Charges for metered water vary. In the older city (old Faridabad, Ballabgarh and authorized colonies), users pay a uniform rate of Rs 1.25 for every kiloliter (KL) of water consumed, while in the regions developed by HUDA and the new colonies developed by builders, there is a graduated tariff structure, as shown in Table 4 below:

Table 4: Tariff for Metered Water in Faridabad City

<table>
<tr><th>Type of Consumer</th><th>Metered water supply (Rupees per 1,000 liters)</th><th>Un-metered water supply (Rupees per 1,000 liters)</th></tr>
<tr><td rowspan="3">Domestic</td><td>Rs. 1.25 per KL up to consumption of 15 KL</td><td rowspan="4">Rs. 50 to Rs. 5000 per month according to the area of the site/ building and the no. of floors</td></tr>
<tr><td>Rs. 2.5 per KL for consumption above 15 KL up to 30 KL</td></tr>
<tr><td>Rs. 4 per KL for consumption above 30 KL</td></tr>
<tr><td>Commercial & Industrial</td><td>Rs. 4.00 per KL (This has been revised upwards to Rs. 15/KL)</td></tr>
</table>

Source: Memo No. 14/90/02-3CII dated 05-02-2003 of Urban Development Dept, Government of Haryana

Discussions with MCF officials suggest that the water charges are not aligned with the cost of production and distribution, which is estimated to be Rs. 11/KL. The tariff structure and consequently poor cost recovery (33%) has drawn the attention of the Accountant General's Office. This would seriously affect the fund flow since MCF will be disqualified from receiving the 13th Finance Commission awards from GoI. Phase II funding from the national government under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) will also not be approved unless MCF revises the tariff and recovers a higher proportion of cost. At risk is an estimated Rs. 20 Billion.

Following the JNNURM guidelines, and with the objective of raising the service standard as well as improving cost-recovery, the MCF has proposed to revise the water tariff as shown in Table 5 (page 19).

Water quality is also emerging as an increasing challenge. Salinity (chloride level upwards of 1,000 milligrams/liter) is reported in groundwater, although other parameters are reported to be within limits. The increase in salinity is reportedly caused by groundwater over extraction by industries. There is an apprehension that more serious problems like arsenic might emerge if this over exploitation continues (NIUA, 2011).

Finally, the volume of non-revenue water (NRW) is estimated by MCF at 52.7%. The MCF attributes this high loss to aging infrastructure: 20% of the pipe line is about 60 years old, 30-40% is about 35 years old, and the remaining 25% of pipes are aged between 10-25 years. On top of this, as mentioned previously, only 52% of the water connections are metered, so total NRW losses are potentially worse, and certainly significant.

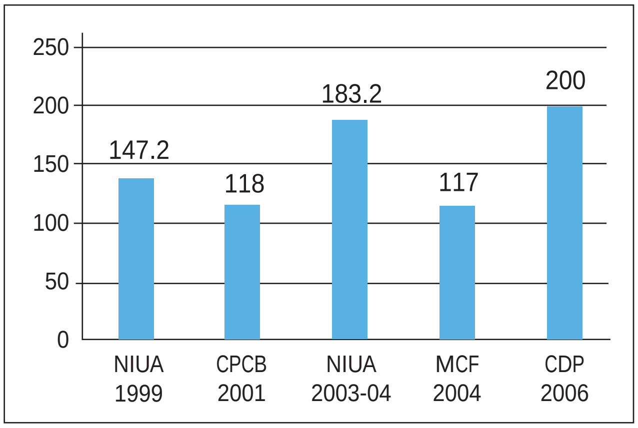
Table 5: Proposed Revised Water Tariffs in Faridabad

User Category	Area	Consumption Level	Rupees per Kiloliter (KL)
Domestic	Old Faridabad, Ballavgarh and authorized colonies	Up to 15 KL	5.00
		15-30 KL	8.00
		>30 KL	13.00
	Regions developed by HUDA and private colonies	Up to 15 KL	5.00
		15-31 KL	10.00
		>31 KL	15.00
Commercial/ Industrial	All	For every KL consumed	20.00

Wastewater Infrastructure

The sewerage network in Faridabad extends over a length of 638 km, covering roughly 52% of the total length of road network in the city (MCF, 2006). There are 73 authorized and 66 unauthorized colonies in the city; sewerage systems have not been built in most of the unauthorized colonies. A National Institute of Urban Affairs (NIUA) report suggests that roughly 50% of the population is not covered by the sewerage system, which means that a large volume of untreated sewerage is flowing into open drains and ultimately into the Yamuna River. Indeed, the City Development Plan of 2006 estimated that as much as 50% of the

Figure 3: Estimate of Domestic Sewage Generation in Faridabad City (Million Lts/Day)



(Figures reproduced from CSE, 2012)

city's total waste was being released untreated into the city's drains and gutters. While 16 proposed Sewerage Pumping Stations (SPSs) have been planned by the MCF, to date only 13 have been installed.

The city is divided into four sewerage zones. Data on domestic sewage generation provided by various sources (at different points in time over 1999 to 2006) range from 118 MLD to 200 MLD (MCF, 2006); these appear in Figure 3. Table 6 shows that the city has three sewerage treatment plants (STP) with a combined capacity of 160 MLD. Each of these plants treats sewage to a secondary level. It is clear that a significant gap exists between the capacity of sewerage treatment plants and the amount of sewage generated. If the current water supply of 240 MLD (assuming full utilization of installed capacity) is considered as the base, approximately 192 MLD of sewage is generated. The installed capacity of the STPs is 160 MLD, indicating a gross gap of 32 MLD. However, STPs may not be functioning at full capacity. For instance, an NIUA survey in 2004-05 found that STPs in Faridabad could treat only 100 MLD.

Table 6: Sewage Treatment Plants in Faridabad

Location	Capacity	Area Covered	Population Covered (Approx.)	Technology Used	Discharge Outlet
Badshahpur	65 (20 + 45) MLD*	Sec 21- Sec 47	266,00	Overflow Anaerobic Sludge Blanket	Budhiya Ka Nalla
Mirzapur	45 MLD	Sec 1- Sec 20, Old Faridabad & Ballabgarh	467,00	Sequential Batch Reactor	Agra Canal
Pratapgarh	50 MLD	NIT Area Dabua Colony, Jawahar Colony, Sec 23, 24, 25	500,000	Sequential Batch Reactor	Gurgaon Canal

* The capacity of the Badshahpur STP was initially 20 MLD, but it has been recently augmented to 45 MLD.

MCF is responsible for Badshahpur STP, while the PHED is responsible for Mirzapur and Pratapgarh STPs. However, the maintenance of all the three STPs has been outsourced to private contractors.

Unfortunately, most of the new colonies are not connected to the sewerage line, so they treat their domestic waste in septic tanks. But very few have added proper soak-pits, and hence the wastewater from septic tanks are discharged untreated into drains, adding to the pollution load. The City Development Plan of 2006 points out two clear policy and governance issues in sewerage management: a) lack of clarity regarding sewer tariffs; and b) absence of coordinated planning among various agencies involved in land use planning in order to allocate space within the city for STPs/SPSs.

Besides MCF and PHED, the Central Pollution Control Board (CPCB) also has a monitoring role for STP operations. In spite of the oversight by all of these agencies, the treatment standards do not meet the expected level. The CPCB, which has assessed the causes of Yamuna River pollution, has identified untreated waste released into Budhiya Nalla as the major polluting source. It drains into the Yamuna some 39 km downstream after the Okhla Barrage.

However, another independent assessment by the Centre for Science and Environment (CSE) says that almost 80% of the city's official wastewater gets dumped into two main drains—Gaunchi and Ujjina—which join the Yamuna further downstream. The CSE report observes severe deterioration in the water quality of the Yamuna River analyzing biological oxygen demand (BOD). The CSE report states that the "…officials of PHED admit that the treated effluents of the three STPs do not meet the required standards and therefore cannot meet the desired 30 milligrams/liter BOD level in the effluents discharged" (CSE, 2012). According to this report, the treated effluent from the STPs over a four month period from September 2005 to January 2006 showed BOD levels higher than 73 milligrams/liter.

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Summary of Climate Change Vunerability

Globally, the issue of sustainable freshwater availability is expected to be exacerbated by climate change (Bates, 2008), and the adverse impacts of a changing climate makes achieving development objectives all the more difficult. Locally, the hydrologic profile of Faridabad illustrates significant water stress, with important vulnerabilities in the short and long-term due to climate change.

The Intergovernmental Panel on Climate Change (IPCC) developed a set of scenarios for greenhouse gas emissions in the future world taking into account different directions of demographic change, economic development, and technological change. Four different storylines called A1, A2, B1, and B2 were developed with different assumptions. Of these storylines, the A1 scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies (IPCC, 2000). The A1 scenario family further develops into three groups describing alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B).

Climate change scenarios for India under the A1B scenario of emissions project a warming on the order of 0.5^0 to 1.5^0C in the 2020s and up to 3^0C in the 2050s, against the baseline of the 1970s. Climate models further project that the maximum warming is expected over the northern parts of India and over the Himalayas (Indo-UK, 2012), with an increase in seasonal (monsoon) rainfall of 10% in the 2020s and 15-20% in the 2050s, against the 1970s baseline.

An analysis of one-day extreme rainfall series based on historical meteorological records in India showed an increase in intensity of extreme rainfall over Gujarat (Saurashtra and Kutch), East Rajasthan, coastal Andhra Pradesh, Orissa, West Bengal and parts of northern India (Indo-UK, 2012). The study also concluded that there was a significant decrease in intensity as well as frequency of rainfall over Chhattisgarh, Jharkhand, and some parts of north India. Faridabad falls in the northern India region and therefore, projected increases in warming and rainfall per the A1B scenario of development are considered applicable to the city. In addition, the intensity of rainfall is also projected to increase for the city.

It is important to note that significant variability in forecasts can occur across the different storylines, and based on different scales of analysis (such as global, regional, local). For purposes of this report, in order to assess the water resource-related vulnerabilities due to climate change,[2] climate events affecting water resources for Faridabad were first identified. Then, the probability of occurrence of these events in the city was determined. The probability of occurrence is the likelihood that such an event may occur, based on a scale of low/medium/high, as presented in Table 7. Upon determining the nature of the impacts from these events (Table 8), the municipality's preparedness is considered to mitigate these impacts.

[2] The IPCC 2000a publication defines vulnerability as "the extent to which a natural or social system is susceptible to sustaining damage from climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes in climate and the ability to adapt the system to changes in climate."

Table 7: Probability of Occurrence of Specific Climate Change Events in Faridabad

Climate Events	Probability of Event	Rationale
Accelerated retreat of the Himalayan glacier Yamunotri	**High**	There have been few studies on the retreat of the Yamunotri glacier (located at 31^{0}N). However, there have been more studies on the Gangotri glacier, located at a comparable latitude of 30^{0}N (but at a higher altitude) and in the same state of Uttarakhand. A study examining 61 years of data (1936-96) shows that the glacier has retreated at an average rate of 19m a year during the period (Shankar, 1999). Between 1996 and 1999, the glacier retreated by a further 76m (Naithani, 2001). While a recent study reveals that glaciers elsewhere in the Himalayas (in the Karakoram mountain range) may actually be enlarging,[3] it may be assumed that the effect of the climate on Yamunotri glacier may be similar to that on Gangotri glacier owing to the geographical proximity of the glaciers.
Scanty rainfall in rainy seasons	**Medium**	Several climate studies report a general trend of a decrease in the number of rainy days and total annual amount of precipitation in many Asian countries.[4] From the monsoon data on the India Meteorological Department's website, the Haryana-Chandigarh-Delhi area has experienced a deficient monsoon (between 20% to 39%) in four out of eight years, between 2005 and 2012.[5] The recent trend indicates that there is a medium probability of occurrence of scanty rainfall during the monsoon season.
Wetter non-rainy seasons	**Low**	The Faridabad area receives the bulk of its rainfall in the monsoon months from June to September. There has been no exclusive study or indication of an increase in off-season rainfall in the area, thus no evidence suggests better than a low probability of the occurrence of wetter non-rainy seasons.
Hotter/dryer summers	**Medium**	The year 2012 recorded a temperature of greater than 40^{0}C in Delhi on 49 of the 61 days in the summer months of May and June.[6] Furthermore, the average maximum temperature in the city has been 41.57^{0}C, making it the hottest summer since the year data has been available (1980). In Faridabad, the maximum summer average temperature was 41.27^{0}C in 2012, as opposed to 38.92^{0}C in 2011.[7] While a trend cannot be drawn based on only two data points, the temperature trend from the nearby city of Delhi and the indication from the climate model of a warming in northern India, both suggest a medium probability of hotter and drier summers for Faridabad.
Storms and intensive rainfall	**Medium**	Many studies report that the frequency of occurrence of more intense rainfall events in many parts of Asia has increased in general.[8] The climate change model for India projects both an increase in quantum of seasonal rainfall and intensity of rainfall in the monsoon months in the northern region (Indo-UK, 2012). Therefore, the climate event is designated a "medium" probability event.

[3] See http://www.foxnews.com/scitech/2012/04/17/some-himalayan-glaciers-actually-growing-scientists-find/#ixzz2BpvYQTOI
[4] Zhai, 1999; Khan, 2000; Shrestha, 2000; Lal, 2003; Ruosteenoja, 2003; Zhai, 2003; Gruza, 2003.
[5] See http://www.imd.gov.in/section/nhac/dynamic/Monsoon_frame.htm and http://www.imd.gov.in/section/nhac/dynamic/weekly_pressrelease.pdf
[6] See http://articles.timesofindia.indiatimes.com/2012-07-03/delhi/32522483_1_maximum-temperature-degree-national-climatic-data-center
[7] See http://www.accuweather.com/en/in/faridabad/202446/june-weather/202446?monyr=6/1/2012
[8] Khan, 2000; Shrestha, 2000; Lal, 2003; Ruosteenoja, 2003; Zhai, 2003; Gruza, 2003, and http://www.imd.gov.in/section/nhac/dynamic/Monsoon_frame.htm

Impacts of Potential Climate Events on the Municipality of Faridabad

Table 8 presents the possible impacts from each of the high and medium probability climate events for the city of Faridabad, with further discussion below.

Table 8: Potential Impacts of Climate Events

Climate Events Related to Faridabad	Potential Impacts	Vulnerability	
		Short-term (2020s)	**Long-term (2050s)**
Accelerated retreat of the Himalayan glacier Yamunotri	Increased melt water in the short term, and eventual loss of the glacier as a water source to the Yamuna River in the long term	**Low**	**Low**
Scanty rainfall in rainy seasons	Reduced recharge, droughts	**Medium**	**High**
Hotter summers	Reduced recharge, droughts	**Medium**	**Medium**
Storms and intensive rainfall	Water logging, floods, reduced recharge	**Medium**	**High**

Increased Glacier Melt

There have been many studies on the melt water discharge and glacier retreat, with results indicating both an increase and decrease in the stream runoff (SERC, 2011; Jain, 2008; Kulkarni, 2004). A preliminary study specifically on the Himalayan catchment further suggests that, owing to the hydrological characteristics of the region, glacier melt would not lead to high discharge or floods under normal circumstances. The highest runoff in a stream occurs as a result of high precipitation, and the glacier component in the stream discharge is highest during the years of low summer runoff (Thayyen, 2010). Therefore, considering that the flow in the river and canal through Faridabad city is regulated through dams upstream, it is expected that the vulnerability of the city to greater melt water from the Yamunotri glacier in the short term is low. Longer term preparedness depends in part on the city's infrastructure maintenance regime.

Reduced Recharge

As per the stage of groundwater development (percentage of annual groundwater draft to net annual groundwater availability) assessed in 2004, Faridabad city falls in the 'critical' category (GoI, 2006b). This indicates that the groundwater development is over 90% exploited, and there is a significant long term decline in pre-monsoon and post monsoon levels of groundwater in the area.

Moreover, the current total demand of Faridabad city is estimated to be 387 MLD, while, as mentioned, the current installed capacity is 240 MLD. Industries extract additional groundwater to close their own demand-supply gap. This is further evidence that the groundwater development in the city is indeed overexploited. The key sources of groundwater recharge are from monsoon and non-monsoon rainfall, canal seepage, and to an extent, treated water from septic tanks. The net annual groundwater availability for Faridabad is estimated to be 550,740 million liters. Of this, about 36% is estimated to come from recharge during monsoon rainfall.

There have been instances of increased salinity reportedly caused by groundwater over extraction by industries. Further, there is an apprehension that more serious problems like arsenic contamination might emerge if this overexploitation continues. Given that there is no established evidence of groundwater aquifer contamination, it is likely that the city can be supported from the groundwater in the region in addition to relying on the river sources. The key issues, however, are insufficient infrastructure to support the demand, lack of water recycling, as well as a lack of controlled recharge from treated water from septic tanks. Moreover, the demand from domestic and industrial users is expected to increase over the short term. Failing to meet the requirements may drive certain industries away from the region, thereby potentially curbing the growth of industrial water demand over the long term.

The key sources of groundwater recharge are from monsoon and non-monsoon rainfall, canal seepage, and to an extent, treated water from septic tanks. The net annual groundwater availability for Faridabad is estimated to be 550,740 million liters. Of this, about 36% is estimated to come from recharge during monsoon rainfall.

Droughts

The Department of Agriculture and Cooperation, Ministry of Agriculture, and Government of India have classified Faridabad city as a chronically drought affected area. Deficient monsoon is one cause of drought, and this exacerbates groundwater overexploitation and insufficient freshwater availability. The impacts of drought as discussed in the Disaster Management Plan by the MCF include loss of crops and livelihoods. It ranks the drought impact as 'moderate.' However, with greater warming in the 2020s and 2050s, it is expected that the water demand-supply gap would also increase. This would further increase the vulnerability of the city with a greater population in the 2050s.

Water Logging and Floods

In the eastern boundary of Faridabad, the Yamuna River often overflows. Other than Yamuna, there are several *nallas* or local streams that increase the number of floods in the area. Excessive rainfall, excessive discharge of water from upstream dams, dam bursts and flashfloods upstream of the Yamuna might also result in a sudden and devastating flood in the district.

The City Development Plan of Faridabad states that storm water drainage networks in the city are inadequate. During monsoon events, the overflow from the primary and secondary drains affects the road infrastructure and damages property in flood-prone areas. This is primarily attributed to silted drains and the absence of serviced storm water drainage areas in the city (MCF, 2006). The City has plans to address the current service gap by 2021 and create new networks in un-serviced and newly developed areas of Faridabad. However, the service gap has been determined based on a population projection that is lower than the actual population increase. The forecast rainfall increase in northern parts of India from climate change models would further add to the challenge. The Disaster Management Plan of the MCF ranks impact from flood as 'high.' Increased flow in the Yamuna, greater rainfall, intense storms, and rainfall over shorter times would increase the vulnerability of the city to flooding events, with the 2050s facing a greater vulnerability than in the2020s if no adequate preparedness measures are taken.

Water Supply and Climate Change Conclusions

The key water resource impacts expected due to climate change in Faridabad point to variability in melt water from glaciers in the Yamuna River, reduced recharge to groundwater aquifers, drought conditions in the city, and water logging or flood events in the city. Based on projected water demand, current practices, and climate projections, the vulnerability of the city to scanty monsoon rainfall, intensive rainfall and storms is determined to increase to high in the 2050s, from moderate in the 2020s. The vulnerability from the accelerated retreat of the Himalayan glacier feeding the Yamuna is expected to be low for the same period, while vulnerability due to hotter and drier summers is expected to be medium across both the short and long term.

Based on projected water demand, current practices, and climate projections, the vulnerability of the city to scanty monsoon rainfall, intensive rainfall and storms is determined to increase to high in the 2050s, from moderate in the 2020s... Climate scenarios only reinforce other findings in this report, and the value of pursuing measures to improve water use efficiency.

In order to decrease vulnerability to reduced freshwater availability in Faridabad, the city should proactively adopt sustainable water resources management principles. Climate scenarios only reinforce other findings in this report, and the value of pursuing measures to improve water use efficiency. Such measures represent "no regrets" actions to improve freshwater availability for the city. For example, stabilizing groundwater levels through artificial recharge, such as through rainwater harvesting and permeable pavement in built areas. Also, as the city is considering decentralized wastewater treatment systems for un-serviced areas, existing or new septic tanks may be fitted in ways to effectively treat sewage and for groundwater recharge, and/or be distributed for reuse by industries. Indeed, all reasonable measures to optimize water use should be seen as critical given the increasing challenge of meeting competing water needs.

3. LEGAL AND POLICY FRAMEWORK RELATED TO WATER USE EFFICIENCY

As stated earlier, water regulation is a “State” subject as defined in the Indian Constitution. However, there is notable national level leadership support for increased water use efficiency. The Government of India's Approach Paper for the 12th Five Year Plan recognizes this need, as does GoI's climate change initiative. Under India's National Action Plan on Climate Change (NAPCC), the National Water Mission (NWM) is one of the eight national-level strategy documents to address water management under a changing climate scenario. The NWM recommends identifying water efficiency improvement as one of the principal measures to improve resilience to the adverse impacts of climate change and has the stated goal of increasing water use efficiency by 20 percent. In addition, the Ministry of Water Resources has announced its intention to launch the National Bureau for Water Use Efficiency. The proposed methods to improve water use efficiency under the NWM are as follows:

- Label water efficient products (similar to the energy efficiency certification provided by the Bureau of Energy Efficiency).

- Minimum standards for water use for commercial buildings (similar to the Energy Conservation Building Code (ECBC) which sets minimum energy performance standards for commercial buildings). Use of water efficient fixtures can be made mandatory in all new construction and remodeling involving replacement of plumbing fixtures in government buildings and commercial complexes.

- Highlight the impacts of savings through using water efficient products so that the general public becomes conscious about adopting these products.

- In the presence of proper water tariffs, water savings can be directly linked with cost savings and thus could be an incentive to adopt water efficient fixtures.

- Provide incentives to save water using labeled products.

- Enact laws which would make it mandatory for the consumers to adopt water saving devices and also ensure strict monitoring for quality parameters.

- Assess the market potential of water saving measures product and the possibility of public private partnerships.

- Funds may be ring fenced (protecting the transfer of assets) for developing water saving measures and assisting potential stakeholders and investors.

Overall, the legal and policy analysis undertaken for this report found that, while some measures to improve water efficiency have been given considerable attention in the law and policy framework, such as rainwater harvesting (RWH), others like wastewater reuse have received little attention, and still others have received no attention at all, such as water efficient fixtures.

For its part, each state government is under an obligation to provide water of a certain quantity and quality to the public. However, the state government can exercise its discretion and devolve this responsibility to urban local bodies. Provision of water to industries located within the city area—typically small and medium-sized enterprises—and disposal of effluents, come under the purview of state level industrial policies. The Municipal Corporations, of course, have their own policies relating to sites and services, which also includes water. Therefore, access to and use of water in Indian cities is guided by a complex set of policies and acts, which sometimes overlap in their jurisdiction.

The legal and policy analysis undertaken for this Guideline found that measures to improve water efficiency have been given some due consideration over the past decade or more, and continue to receive greater attention. As a starting point, though, any effective legal framework requires (1) standards; (2) a management control tool such as licensing or permitting; (3) enforcement monitoring, complete with an established frequency as well as a reporting mechanism; and (4) meaningful sanctions, or consequences for non-compliance. This can be supplemented with well conceived incentives that encourage behavior change and provide the needed support to facilitate compliance and ensure the success of such policies.

Overall, the legal and policy analysis undertaken for this report found that, while some measures to improve water efficiency have been given considerable attention in the law and policy framework, such as rainwater harvesting (RWH), others like wastewater reuse have received little attention, and still others have received no attention at all, such as water efficient fixtures. Furthermore, while there have been a spate of law and policy developments at the state level and practical action in other cities (such as the ban on the use of groundwater for construction purposes in Gurgaon),[9] Faridabad has lagged behind.

The existence of multiple institutions with responsibilities for water and sanitation at the city level has contributed to fragmentation and uneven outcomes. For instance, while implementation of some of measures is mandatory in areas falling under HUDA's purview, the municipal corporation has not been successful in operationalizing rooftop rainwater harvesting. The officials of the

[9] The situation in Gurgaon has been tested and upheld in the courts. In *Sunil Singh* v. *Ministry of Environment & Forests and Others*, the Punjab and Haryana High Court barred HUDA from sanctioning building plans for construction in Gurgaon using groundwater for construction work. In fact, the court directed HUDA to seal and dismantle all the bore wells being used for extracting groundwater at construction sites.

municipal corporation recognize the problem and acknowledge that water efficient technologies ought to be implemented, but cite the lack of capacity (in terms of qualified personnel, finances, and technologies) as key reasons for the state of affairs.

Haryana Municipal Legal and Policy Framework with Special Reference to Faridabad

There are a number of laws in Haryana State that relate to or affect the potential for water and wastewater recycling and reuse, and water use efficiency in particular cities. Notably though, Faridabad is the only town in the State of Haryana where the Municipal Corporation is responsible for water supply rather than the PHED. MCF is responsible for the provision and implementation of all core municipal services, including water supply and sewerage, in its jurisdictional area. However, MCF shares its responsibilities for the provision of services with other agencies, notably the Housing and Urban Development Authority (HUDA), the Town and Country Planning Department, the Haryana Housing Board, and the Haryana State Industrial Development Corporation (HSIDC).

The Haryana Urban Development Authority Act, 1977 established HUDA to assume responsibilities relating to planned development of urban areas, which were previously handled by individual government departments. HUDA provides services in the areas they are developing, and then transfers these areas/sectors to MCF for maintenance purposes after five years. On the other hand, the Town and Country Planning Department prepares and notifies the Development Plan for MCF as well as FCA areas, but it is not responsible for its implementation.

Another somewhat unique characteristic is that Faridabad is one of the Central National Capital Region cities (NCR). The National Capital Region Planning Board Act, 1985, which established the National Capital Region Planning Board (NCRPB) in the Ministry of Urban Development, Government of India, is applicable to the whole of the District of Faridabad comprising the Tehsils of Ballabgarh, Palwal and Hathin. The NCR Regional Plan 2021, which was approved and notified in 2005, lists a large number of projects involving Faridabad with suggested policy changes, strategies, and implementation plan. It includes proposals in the water sector as well as for sewerage, solid waste management, and drainage.

A discussion on some of the key laws and policies currently in place, or proposed, in the area of water use efficiency, follows.

Water Conservation

Water conservation is the main focus of the Draft State Water Policy 2011. The State Environmental Impact Assessment Authority (SEIAA) Haryana is responsible for granting prior environmental clearance for large construction projects in accordance with the Environmental Impact Assessment notification 2006 (amended in 2009). In this regard, the Ministry of Environment and Forests has issued a manual on norms and standards,[10] which includes the following mandatory criteria, among others:

- Use of low flow/dual flushing devices for water closets.
- Separation of gray and black water using dual plumbing line.
- Treated wastewater/sewage shall conform to discharge standards.
- 100 percent treatment of graywater in decentralized sewage treatment plant and reuse for flushing, gardening etc. within premises.
- Rainwater harvesting—storm/rainwater control and reuse is mandatory and the system must adhere to Central Ground Water Board (CGWB) and Bureau of Indian Standards (BIS) provisions for reuse in various applications.

The State Urban Water Policy 2012 further prescribes the following:

- Mandatory metered connections to consumers in domestic, commercial, industrial and institutional sectors in private, semi-government and government premises.
- Convert existing unmetered water connections into metered ones within a period of one year from the date of notification of the policy (i.e. 30 April 2012)
- Consumers will be billed on the basis of volumetric consumption of water instead of flat rates.

The authorities responsible for supplying drinking water would sanction only metered connections for any type of consumers for drinking water henceforth. The proposal is that any water connection remaining unmetered after the lapse of one year from the date of notification of the policy will be charged at the penal

[10] See Government of India, Ministry of Environment and Forests, *Manual on norms and standards for environment clearance of large construction projects* (undated). http://envfor.nic.in/divisions/iass/Construction_Manual.pdf

rates to be fixed by service providing authorities with a provision for disconnection. Importantly, the proposal is to eliminate flat rates in favor of consumption-based tariffs. Furthermore, no water connection with ferrule size of more than 10mm diameter for domestic consumers would be allowed, except for multi-houses and commercial, industrial, institutional establishments.

In recent years, the growing water scarcity in cities has prompted the State Government to promote water conservation measures and to adopt water efficient technologies. In July 2012, as part of its Master Water Supply Scheme, the State Government approved a project to lay an 18 km pipeline to supply recycled water to residential, commercial, and government offices in Gurgaon. This is expected to reduce demand for, and use of, potable water for gardening, washing vehicles etc.

The Industrial and Investment Policy 2011 also includes a restrictive list of industries (GoH, 2011), whereby the state is not to attract the listed industries due to associated water scarcity, pollution, or planning concerns. Financial incentives approved under the policy would also not be available to these industries.

...the State Government has constituted a Water Conservation Mission to promote a holistic approach to water conservation by creating awareness among various stakeholders and the general public. The decision to constitute the mission has been taken to evolve "collective action for water management" in light of dwindling water resources.

From an institutional standpoint, the State Government has constituted a Water Conservation Mission to promote a holistic approach to water conservation by creating awareness among various stakeholders and the general public. The decision to constitute the mission has been taken to evolve "collective action for water management" in light of dwindling water resources. The government has also constituted a special water conservation cell in the irrigation department under the chairmanship of Commissioner, Irrigation Department, GoH, to assist the mission. The cell would also take stock of the existing water conservation practices adopted by various groups of water users in the state. In March 2011, the State Government decided to constitute a committee under the chairmanship of financial Commissioner and Principal Secretary, Agriculture, GoH to prepare the draft of Haryana Water Control and Regulation Bill to address the twin problem of the declining water table in fresh water zones, and rise of the water table in brackish water zones of the state.

Rainwater Harvesting

Rainwater harvesting (RWH) involves the collection, storage and use of rainwater to fulfill certain water requirements other than for drinking purposes. RWH has been made mandatory in a number of state level and city level laws, bylaws, rules and/or regulations. Flowing from the national level, one of the optional reforms under the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) is "[R]evision of building bye-laws to make rainwater harvesting mandatory in all buildings to come up in future and for adoption of water conservation measures."

Unfortunately, while this requirement has been incorporated into regulations, in many cases it does not cover all the necessary parties (many regulations apply to buildings of a certain minimum area, new buildings only, etc.), and even otherwise, implementation has been poor despite the creation of a system of incentives and disincentives.

This notwithstanding, rainwater harvesting has been included in an increasing array of state level instruments. The Haryana State Groundwater Management and Regulation Bill, 2008 considers it “essential to undertake groundwater recharge through rainwater harvesting and using water from other sources in all residential, commercial and other premises and open spaces in the manner prescribed” (section 23). The draft law requires local authorities to impose a condition for providing appropriate rainwater harvesting structures in the building plans having roof top area of 500 m^2 or more. The Bill has not yet been adopted.

The Haryana State Groundwater Management and Regulation Bill, 2008 considers it “essential to undertake groundwater recharge through rainwater harvesting and using water from other sources in all residential, commercial and other premises and open spaces in the manner prescribed” .

Also, the Haryana Urban Development Authority Regulations, 1979 were amended in 2001 to make RWH mandatory for new buildings on plots allotted by HUDA where the roof area is 100 m^2 or more (bylaw 81A, HUDA, 2001). In 2002, an almost identical provision was inserted in the Haryana Municipal Building Bylaws, 1982 that makes RWH mandatory for new buildings on plots with a roof area of 100 m^2 or more—failing which the Occupation Certificate will not be issued. Then in August 2002, at the fourth meeting of the Water Conservation Commission, the Haryana Government decided that the construction of RWH structures would be made mandatory in all government as well as HUDA buildings. Rooftop rainwater harvesting has been made mandatory for all HUDA buildings with a covered area of 250 square yards or more.

Also, the Punjab Scheduled Roads and Controlled Areas Restriction of Unregulated Development Rules, 1965 were amended in 2007 to insert a provision for rainwater harvesting (GoH, 2007). This stems from the Punjab Scheduled Roads and Controlled Areas Restriction of Unregulated Development Act, 1963, which was enacted to prevent haphazard and sub-standard development along scheduled roads and in controlled areas in Haryana. The Rules state:

122-ARainwater Harvesting (Sections 8(2) and 25(2)(f))

(1) Arrangement of roof top rainwater harvesting will have to be made by the plot-owners on the plots in the buildings constructed in the colonies for which license has been granted under Act No. 8 of 1975, or where permission for change of land use has been permitted and where the area of the roof is 100 square meters or more.

At the city level of Faridabad, the MCF has made rainwater harvesting mandatory in all new buildings having rooftops with an area of 100 m^2 or more since 2006-2007 (GoI, 2006a and 2006c). The CGWB declared the Municipal Corporation of Faridabad and Ballabhgarh as a “notified area” (NOC) for control and regulation of groundwater in 1998 (CGWB, 1998). The CGWB has made rainwater harvesting mandatory in all institutions and residential colonies in notified areas. This has also been made applicable to all the buildings in notified areas having a tube well, and 31 March 2002 was fixed as the deadline for compliance. The CGWB also banned tube well drilling in notified areas (UNESCAP, 2012).

In October 2009, CGWB directed all the residential group housing societies, institutions, schools, hotels, and industrial establishments falling in the over-exploited and critical areas in Faridabad (among others) to adopt rooftop RWH systems on their premises. These systems were to be completed by May 2010 so that they were effectively operational in the monsoon of 2010 (CGWB, 2009). Further to the 2009 directions, in 2010, CGWB directed all the large and medium industries (existing and new) using groundwater to take up water conservation measures including groundwater recharge, rainwater harvesting, and the treatment, recycle and reuse of wastewater on their premises. All the industries using groundwater were required to provide information about implementation of such practices to the authorized officers concerned at the State Pollution Control Boards/State Ground Water Boards (CGWB, 2010).

For the city itself, according to a Detailed Project Report, 150 rainwater harvesting structures were to be constructed to augment Faridabad's water supply, of which 117 have been completed and 13 are in progress. According to a news report, MCF has constructed around 110 rainwater harvesting pits, nearly 70 pits of which are in working condition, though the other 40 are lying defunct.

Treatment, Recycling and Reuse of Wastewater/Graywater

The pace to enact new laws, or amendments of existing laws, to incorporate graywater recycling as a requirement has been slower than for rainwater harvesting. The enactment of bylaws on reuse of recycled graywater has been recommended as an optional city level reform under JNNURM. As such, some cities covered by JNNURM have drafted such bylaws and a few of them have already implemented them. At present, Faridabad does not have bylaws for reuse of recycled water (GoI, 2012b). However, the local government is keen to implement such a measure, funding permitting. The State Government has also constituted a committee to prepare the draft bylaws on wastewater reuse (MCF-JNNURM, *supra* note 23).

The National Capital Region Planning Board's Regional Plan 2021, which is applicable to Faridabad, also encourages recycling of wastewater for non-drinking use. It states:

> *All new development areas should have two distribution lines, one for drinking water and other for non-drinking water/recycled treated waste water to reuse the treated waste water. All the waste requirements for non-drinking purpose in big hotels, industrial units, air-conditioning of large buildings/institutions, large installations, irrigation of parks/green areas and other non-potable demands should be met through treated recycled waste water as per norms. At least 50% of the treated waste water should be recycled for these purposes and emphasis should be laid towards waste minimization, which will also help in improving the environment on the whole. Government may also provide liberal tax rebates for institutions/industries adopting recycled waste water to compensate for the cost involved in treating waste water for recycling...If required, enabling provisions in the respective acts of the local bodies may be made by the respective State Governments* (NCRPB, 2005).

The Haryana State Groundwater Management and Regulation Bill, 2008 includes a provision encouraging wastewater reuse by infrastructure developers, special economic zones (SEZs), multiplexes, industrial and housing societies...

During the 10^{th} Plan Period (2002-2007), recycling of wastewater for non-drinking use was to be initially implemented in institutions, hotels, and new colonies proposed or under development. The State Government had the discretion to make enabling provisions in the acts of the local bodies. Thereafter, it was to be implemented and monitored on regular basis by the respective State Governments (NCRPB, 2005). A committee has been constituted by the State Committee to prepare the draft bylaws on reuse of recycled water (MCF-JNNURM, undated).

The Haryana State Groundwater Management and Regulation Bill, 2008 includes a provision encouraging wastewater reuse by infrastructure developers, special economic zones (SEZs), multiplexes, industrial and housing societies to consider reuse applications such as for irrigation, flushing, vehicle washing, and central cooling.

In June 2012, the Haryana State Irrigation Department was expected to come out with an executive order making it mandatory for all new residential, commercial and industrial sectors to achieve zero water waste by conserving and reusing wastewater. The government would only keep supplying 20 percent water for drinking purposes and the agencies or companies developing any area would be responsible for 100 percent recycling and wastewater reuse. Recycling and reuse would be linked to the provision of licensing for developing any real estate project. The Irrigation Department was also considering a proposal to supply only recycled water to companies for industrial use. However, no further information is available on this order. More recently, the Chief Minister has directed PHED officials to formulate projects for the reuse and recycling of treated wastewater.

Efforts are also underway to promote recycling and reuse of industrial effluents. This is one of the long-term action points under the Action Plan for Abatement of Pollution for Faridabad Town (HSPCB, undated). The State Pollution Control Board will pursade large and medium industries to adopt the latest clean technologies for this purpose.

By the same token, the proposed strategies to achieve the objectives set out in the Industrial and Investment Policy 2011 also include “[E]fficient use of water resource, treatment, re-cycling of waste water...” (GoH, 2011). Except under exceptional circumstances, the HSIIDC is responsible for developing the minimum planning norms for various infrastructure facilities. These include:

- Treatment and re-cycling of water for which dual pipelines (for fresh water and reuse water) will be laid.

- Every estate will be provided with a sewage treatment plant/common effluent treatment plant, as per requirements, which would be operated in the PPP mode with pre-defined treatment standards (GoH, 2011).

There is also ample scope for private sector participation in managed services in the industrial estates developed by the HSIIDC. This could include building, operating and maintaining the STPs/CETPs, as well as the provision of water supply, distribution, treatment, recycling and management solutions (GoH, 2011).

The HSIIDC suggests laying dual pipelines for supply of fresh and reuse water so as to target a situation of zero discharge from its specific industrial sectors within a reasonable time-frame (GoH, 2011). There are several cases where voluntary initiatives have been undertaken by industries. For example, Ion Exchange has commissioned a contract for wastewater treatment and recycling (3,600 cubic meters/day) and a 370 cubic meters/day STP for Maruti's expansion project in Manesar, Haryana; the recycled water will be used in the paint shop and for manufacturing purposes.

Legal and Policy Conclusions

The legal and policy framework related to water conservation applicable to Faridabad shows mixed signals and results. On the one hand, measures to encourage rainwater harvesting have been given significant attention, while on the other, provisions for wastewater reuse notably lag and flow and consumption requirements for fixtures and appliances are absent entirely. The landscape is complicated by the various institutions responsible for water and sanitation, as well as inadequate personnel and resources (financial and technological). This leads to a situation where the diverse initiatives undertaken do not add up to a comprehensive and holistic policy for advancing water recycling and reuse, and for achieving water use efficiency.

However, the future should be more promising for several reasons. First, the growing specter of water scarcity is creating a public demand for alternatives to the status quo and creating the necessary impetus for the government to implement water efficiency measures. Second, related developments in other cities in the state (e.g. the ban on use of groundwater for construction purposes in Gurgaon) may create a demand for similar regulation in Faridabad in the near future. Third, as a beneficiary of national level policies and programs, such as the JNNURM, Faridabad is likely to feel the pressure to replicate water use efficiency initiatives that are being presently undertaken in other JNNURM cities. Last, the increasing focus on the impacts of climate change on the water sector at the national level, and the adoption of corresponding measures to improve water use efficiency, are likely to have a trickle-down effect resulting in the adoption of various state and city level measures. However, it is imperative that this is accompanied by implementation and monitoring mechanisms in order to ensure the effectiveness of such actions.

4. WATER USE SURVEY

Survey Methodology and Scope

WAISP conducted a survey of 14 different categories of water use in Faridabad during October 2012 to obtain an up-to-date assessment of trends in water use practices, and in order to identify opportunities to improve water use efficiency. The survey instruments (questionnaires used by the survey team members during their in-person interviews with survey respondents) were designed separately for each category of water use. The residential sector was afforded the longest set of questions because of its large role in urban water demand and consumption. Other categories of water users were given shorter survey instruments, with varying types and numbers of questions in order to elicit the most relevant responses particular to those categories.

Most surveys, for example, asked questions about the source(s) of water supply, metering, number of people served, number and types of WCs, number of showers and faucets. Also, questions were asked about water using appliances such as washing machines, dishwashers, and desert coolers, including the type and frequency of use. Surveyors also asked about the size of gardens or landscaping (if any), and asked how irrigation was performed. They also asked about cleaning practices around the facility and for any vehicles, as well as water storage facilities available. The surveyors asked whether rainwater harvesting is practiced, and if routine water audits or other water conservation measures are performed. For the residential surveys, teams gauged the income level of households to try to ascertain differences in water use by low, middle and high income groups.

An overall target sample size of 500 was planned and divided among the various water using categories (494 surveys were actually completed). Residential domestic users represented the largest share of respondents (294), while swim clubs, laundries, and crematoria represented the smallest number of samples. The sample size is deemed sufficient for most categories to enable data analysis and factual enumeration of responses, though responses may not be representative of the sectors for which only a few surveys were conducted. Due to time constraints, it was not possible to collect certain kinds of quantitative data, such as leakage rates or actual costs paid for water. These factors notwithstanding, information gleaned from the surveys provides insights and trends on current water use, and provides lessons and helps identify opportunities to achieve water use optimization.

Table 9 provides a summary tabulation of the survey, with summary descriptive narratives of the survey data results following. These summaries inform the recommendations and opportunities presented in the next section of this report.

Most surveys asked questions about the source(s) of water supply, metering, number of people served, number and types of WCs, number of showers and faucets. Also, questions were asked about water using appliances such as washing machines, dishwashers, and desert coolers, including the type and frequency of use.

Table 9: Summary of Selected Results from Faridabad City Survey of Water Use Patterns

Water use category	Number of surveys completed	Source of water, %				Water metered?		Average water consumption, L/d	Rainwater harvesting		Water filtered?	
		Mun-icipal	Own source	Both	Tanker	% Yes	% No		% Yes	% No	% Yes	% No
Residential	294	73	12	8	6	32	68	NA	6	94	63	37
Schools	62	82	15	0	3	NA	NA	NA	6	94	NA	NA
Religious Centers	31	63	33	0	3	23	77	1,081	NA	NA	NA	NA
Healthcare Fac.	30	97	3	0	0	67	33	4,972	NA	NA	90	10
Service Stations	20	40	30	0	30	50	50	1,409	5	95	NA	NA
Hotels	19	63	37	0	0	53	47	3,066	NA	NA	NA	NA
Restaurants	10	45	45	0	10	40	60	3,643	NA	NA	20	80
Government	10	80	20	0	0	NA	NA	NA	NA	NA	NA	NA
Gardens, Parks	5	0	67	0	33	0	100	23,750	33	67	NA	NA
Transportation	4	50	25	0	25	25	75	8,125	NA	NA	NA	NA
Shopping Malls	4	0	75	0	25	0	100	39,500	0	100	100	0
Laundries	2	100	0	0	0	100	0	2,000	NA	NA	NA	NA
Crematoria	2	100	0	0	0	0	100	1,350	NA	NA	NA	NA
Swim Clubs	1	0	100	0	0	50	50	250	NA	NA	100	0
Total Sites Surveyed:	**494**											

***NA = Not Available; either the question was not asked, or the response was not provided.**

Survey Findings

Residential

The focus of the survey was on domestic water use, covering 294 households from residential clusters representing different areas of Faridabad. Survey samples included the core city, suburbs, and extended suburbs. Over half of the respondents were middle-income group households (MIG, 58%), while the rest were high-income (HIG, 27%) and low-income (LIG, 15%).[11] The majority of residences surveyed receive water exclusively from the municipal supply (72%). Water from the municipal system is available an average of 2 hour 43 minutes per day, most have access to water twice per day (72%). The remaining households receive water only once per day. A few households that receive water from the municipal system also have a private source (8%). Of the other households, 12% exclusively have a private water supply, and 6% depend on tanker truck delivery. The water connection to just 32% of the respondent homes is metered, although 77% of those meters were nonfunctional at the time of the survey.

[11] Due to the complexity of verifying accurate household income, the survey team judged income level based on the appearance of the home and neighborhood and did not specifically request income data from respondents.

- Over one fourth of the homes surveyed have more than three bathrooms (WCs), and many more have two bathrooms. Another fourth have one bathroom, and 6% have no WC. Most of the WCs are single flush (over 65%), or pour flush. Only 7% of surveyed households have efficient dual flush Wcs.

- Most of the residences surveyed have washing machines, and out of the 215 homes with washing machines, 60% were the less efficient top-loading machines. Only 31 surveyed households own a front-loading machine, representing 15% of the sample. Front-loading washers average about 18 liters of water per load, while top loading models use 24 liters per load. Nobody reported having a dish washing machine.

- Almost two-thirds of all residences surveyed filter their water before use.

- Nearly 40% of the residences surveyed cultivate a home garden. Virtually all residents water their gardens by hand, either with a hand-held hose or with a bucket. Sprinklers are used only by 2% of respondents, and none of the respondent uses drip irrigation—the most advanced and the most efficient method of irrigation.

- Ninety-five percent of respondents reported having at least one vehicle, whether a car, motorcycle, three-wheeler, or other type of motor vehicle. About half of respondents wash their vehicle with water, while the other half usually wipe it clean with a cloth.

- Desert coolers are in use at 176 residences, evaporating considerable water in the process of providing air-conditioning for interior spaces.

Household water storage in buckets

Pour flush WC

·Photos: AIILSG

Schools

Nearly all of the schools surveyed (82%) are connected to the municipal water system, while 9 schools are supplied with water from their own sources, and two are supplied by tanker truck.

- Schools reported between two and 90 WCs per site, with an average of 11 toilets per school. Three quarters of the schools have single flush toilets, with the other quarter using pour flush WCs. No schools surveyed have the more efficient dual flush models.

- The 62 schools reported an average of 12 faucets per school. Most schools reported no showers, though the largest school maintains up to 310 showers.

·Photos: AIILSG

School drinking water taps with automatic shut-off

School drinking water taps left open

- Landscaping area varies widely among schools, with the largest schools maintaining up to 65,000 ft^2 and 16,000 ft^2 of playground. All landscaped areas are reported to be watered manually with a handheld hose (90%) or bucket (10%).

- Schools maintained between zero and 43 vehicles, for an average of three vehicle per school. More than half of the schools reported their method of cleaning school vehicles. Nineteen (31%) use water to wash their vehicles, while 12 (19%) usually wipe the vehicles with cloth, and five use other methods.

- Four of the 62 schools practice rainwater harvesting.

Religious Centers

Nineteen of the religious sites are connected to the municipal water system, and ten sites have their own source of water; one center purchases water from tankers. The majority of respondents reported that their water use is not metered.

- More than half of the religious sites have single flush WCs. Five of the mosques and temples are equipped with pour flush WCs.

- Although not all of the religious sites have landscaping, the largest temple reported 2,000 ft^2 of landscaping. On average the temples maintain about 786 ft^2 of landscaped area per site. Most of the religious sites are watered by hand (handheld hose or bucket).

- In religious centers, a minority of staff and worshippers expressed awareness of the need for water conservation.

Healthcare Facilities

Nearly all of the healthcare facilities surveyed are served through connections to the municipal water system. However, only 20 of them are metered.

- The healthcare facilities have an average of 13 toilets each. The largest facility reported 70 WCs on site. All of the facilities are equipped with single flush toilets, and not one healthcare facility has efficient dual flush toilets.

- An average of 1,150 liters of water per day is used for dialysis at the healthcare facilities, with one facility reporting a maximum use of 2,000 L/day

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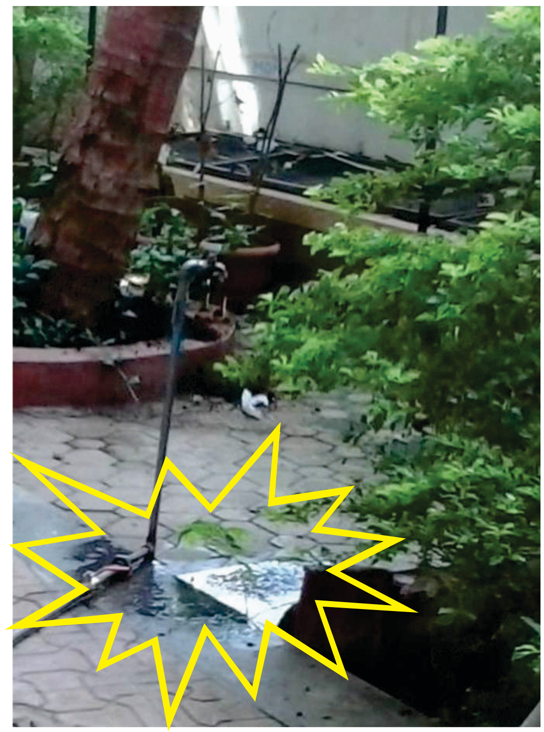

·Photo: AIILSG

Leakage from a garden tap.

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- Although not all of the religious sites have landscaping, the largest temple reported 2,000 ft^2 of landscaping. On average the temples maintain about 786 ft^2 of landscaped area per site. Most of the religious sites are watered by hand (handheld hose or bucket).
- Most of the healthcare facilities perform some type of water treatment, with 11 treating water through granular media filtration, and 16 through reverse osmosis membrane treatment. Of those treating their water supply, 10 reported reusing their filter reject water for landscape irrigation.

Service Stations

Eight of the 20 surveyed service stations receive municipal water supply, and half of the service stations report a metered connection. Six of the remaining service stations supply water from their own sources, and six other service stations receive water by tanker truck.

- Thirteen of the service stations offer manual car washes, while only 5 provide a mechanical carwash. Four of the service stations re-circulate the wastewater from car washes.

- Service stations maintain between zero and ten WCs for employees and customers. Service stations average three toilets per site. Eight of the service stations are equipped with single flush toilets, seven have pour flush WCs, and none have efficient dual flush toilets.

- Some of the service stations have landscaping, with an average of 252 ft^2 of landscaped area per site. Four of these sites are watered manually with handheld hose.

- One service station harvests rainwater, and one reuses water. Two stations claimed to use “less” water.

Photo: Bahman Sheikh

Water-wasting "rainshower" in a 3-star hotel bathroom

Hotels

Of the 19 surveyed hotels, 12 are connected to the municipal water system. The other seven hotels have their own source of water. Ten hotels indicated that they have metered connections.

- The surveyed hotels average 20 bathrooms, or about one WC per guestroom. The largest hotel had 50 bathrooms. Most of the Faridabad hotels are equipped with single flush toilets, while two hotels have the more efficient dual flush models.

- The largest hotel reported having 25 kitchen faucets, though the 19 hotels averaged six faucets per facility.

- Only one of the hotels has mechanical dishwashers, which uses an average of 60 liters of water per day.

- While all surveyed Faridabad hotels provide some form of air conditioning, the majority use air cooled refrigeration technology, and only eight of the surveyed hotels use water cooled systems.

- Six of the hotels reported filtering water before use, and six others treat with reverse osmosis. Another seven hotels indicated "other" treatment systems.

- While not all Faridabad hotels surveyed have landscaping, on average the hotels have about 168 ft^2 of landscaped area, with the largest hotel reporting over ten times that average (2,000 ft^2). Five hotels irrigate their landscaping manually with a handheld hose or buckets. One hotel uses movable sprinklers.

- One of the 19 hotels surveyed has a swimming pool, which they cover during periods of non-use.

- Staff at just seven of the 19 hotels evidenced awareness of the importance to conserve water. Only five of the hotels reported that lodging guests have a similar awareness.

- The majority of the hotels (95%) have no current water conservation efforts or plans to prevent water waste. Only one hotel indicated that it prevents water waste, although fully 10 hotels reported that they audit their water use.

Restaurants

Half (5) of the restaurants surveyed receive water from the municipal water system. The other half have their own source of water, and one depends on tanker water. Four of the water connections are metered.

- Restaurants report between zero and five WCs per site, with an average of two toilets per restaurant. Seven of the 10 restaurants have single flush toilets, two restaurants are equipped with dual flush toilets. The restaurants surveyed also reported an average of three urinals per site. One restaurant uses urinals with sensors, which also promotes better hygiene.

- Seven restaurants report that they wash their WCs regularly with water, while one mops them. One restaurant sweeps them clean, without using water.

- Six of the 10 restaurant sampled treat their water in some way.

- Only three of the surveyed restaurants use mechanical dishwashers. While the remaining seven restaurants wash dishes by hand, six of them admit to washing utensils under constantly flowing water; six report that they use water to thaw frozen food.

- Restaurants that maintain landscaping have an average of 1,629 ft^2 of landscaping, with a range of 100 to 4,000 ft^2. Two restaurants irrigate with a handheld hose, and three use buckets.

- None of the 10 restaurants reported any type of future water conservation plan.

Government Offices

Eight of the ten government offices surveyed are connected to the municipal water system.

- The size of the government facilities surveyed in Faridabad varies widely: the largest office building has 30 WCs, while the smallest office has only 2 WCs, for an average of nine WCs per building. Seven of these are equipped with single flush toilets, while the remaining three offices use manual pour flush WCs.

- All surveyed government facilities are landscaped, with the largest facility managing 4,000 ft^2, including 2,700 $ft^2$of lawn. On average, government offices maintain 1,268 ft^2 of landscaped area and 1,312 ft^2 of lawn. Landscape irrigation is almost entirely performed manually with a handheld hose or bucket.

- One of the 10 government offices washes vehicles with water. Two other offices wipe the cars clean with a cloth.

- None of the government offices indicated they have any existing or planned future water conservation measures.

Photo: AIILSG

Public Garden in Faridabad

Gardens and Parks

None of the gardens surveyed are connected to the municipal water system, and none have a meter. One garden has its own source of water, and the other receives water from tankers.

- Nearly all of the parks and gardens maintain WCs at their facilities, the largest of which has six toilets, with an average of two WCs per garden. Two of the gardens have pour flush WCs, and the remaining sites are equipped with single flush toilets. None of the gardens have efficient dual flush toilets.

- Landscaped area at the gardens ranges in size from as small as 5,000 ft^2 to over three million ft^2. The average landscaped area per survey garden is 983,400 ft^2. On average, landscaped area in the gardens is mostly comprised of grass (ranging from 50 to 90%), with smaller areas dedicated to trees (10 to 25%) and shrubs (1 to 25%).

- Most of the gardens in Faridabad are watered by a handheld hose. One park is irrigated with movable sprinklers.

- Only two of the gardens augment their water supply with rainwater.

- Though one garden reported that it takes steps to prevent water waste, no gardens claim to have water conservation plans in place.

Transport Facilities

Two of the four transportation hubs surveyed receive water from the municipal water system. The other two receive water from their own source and from tanker trucks; however, only one of them has a meter. Food stalls at transportation centers also obtain water from municipal, tanker, and their own sources.

- Water is available for drinking at three of the five transportation hubs, and one of them provides water for hand washing.

- All transportation hubs provide WCs, with the largest having up to seven. On average, transportation hubs maintain four WCs per site, with mainly pour flush toilets, and only one with single flush.

- All four hubs wash the floors with water. The frequency of cleaning is once per day. They also clean the WCs daily, with three of the hubs washing the WCs and one only sweeping.

- All four transportation centers surveyed in Faridabad report landscaped areas of zero to 2,100 ft^2, with an average of 525 ft^2. All reported irrigating with a handheld hose.

Photo: AIILSG

Running hose at a bus depot

Shopping Malls

None of the shopping malls are connected to the municipal water system. Three have their own water source and one receives water from tanker trucks.

- Surveyed shopping malls report between 15 and 26 WCs per site, with an average of 19 toilets per shopping mall. All four malls are equipped with single flush toilets.

- Two malls reportedly treat water, while the other two do not.

- Two of the malls sweep the floors clean and the other two wash the floor with mops. Frequency of cleaning varies from three times per day in two malls to four times per day in the other two.

- Three of the four shopping malls have landscaping and irrigate an average of 7,000 ft^2. The largest landscaped area covers an area of 20,000 ft^2 while the smallest is 1,500 ft^2. Three irrigate with a hand-held hose, and one uses a movable sprinkler.

- One mall reported to be recycling water.

Other Categories

Of the remaining categories, the small survey samples suggested the following.

- The two crematoria surveyed depend on municipal water supplies, but are unmetered. One uses a dual flush WC, and cleans with water. Both crematoria water their landscaped areas with a handheld hose.

- Both of the two laundries surveyed are connected to the municipal water supply and have meters. One is equipped with a top-loading machine, while the second establishment washes laundry by hand. Both discharge water to the sewer and neither one reuses water or has plans to conserve water in the future.

- The single swim clubs surveyed has a private water supply. The club reuses filter backwash water for irrigation, but does not recycle shower water. The club did not report a water conservation plan or efforts to prevent water waste.

Photo: AIILSG

Open-air laundry (dhobhi ghat).

5. OPPORTUNITIES AND RECOMMENDATIONS FOR WATER USE EFFICIENCY

Water Conservation Opportunities

Across developing countries worldwide, the cost-benefit of water conservation practices can rarely be calculated on the basis of the exceedingly low tariffs charged, which often do not recover operations and maintenance costs. Even so, it is generally less costly and more sustainable to pursue efficiency measures than solely invest in new supply infrastructure. Below we present numerous water conservation approaches and concepts based on the survey result outcomes, as well as global best practices.

Rainwater Harvesting

The government has made efforts to promote rainwater harvesting, but our survey shows an indifferent response from households dependent on municipal water supplies. At the same time, because the monsoon rains are restricted to a few months per year in Faridabad, investments at the household, colony, or municipal level require more in-depth analysis regarding issues such as storage capacity, catchment areas, as well as water quality maintenance and water use applications.

One option would be for the city to provide a connection line to collect rainwater from colonies in order to directly recharge groundwater. Alternatively, investments in decentralized storage capacity could supplement water available for irrigation, cooling, toilet flushing, and other uses.

Again, an analysis by the government is warranted to calculate the cost effectiveness and examine a variety of conditions such as catchment size, area served, demand for water, type of demand to be met, etc. Unfortunately, however, the traditional cost-benefit comparisons are not adequate to the task because of the artificially low value price of water.

Photo: Bahman Sheikh

Scale model of a community level rainwater harvesting system

Photo: US Dept. of Agriculture

Rainwater harvesting storage tank

Permeable Pavement

Worldwide, an unfortunate consequence of urbanization is that the ground surface becomes increasingly covered with impermeable features, such as asphalt parking areas, sidewalks, and streets. This results in grossly reduced natural recharge of the groundwater during rainfall events. Instead, the rainfall causes flooding and forms pools of water that eventually evaporate into the atmosphere, or ends up as runoff into surface rivulets and drains away from the city. Groundwater being an essential source of water supply for Faridabad, a key water saving action would be gradual replacement of paved surfaces with appropriate permeable pavement materials and water absorbing/infiltration construction. This would complement rainwater harvesting efforts, and could be pursued by the municipality through public-private partnership schemes. Public parking surfaces and walkways in parks and other public places would be the first candidates for such conversion. A municipal requirement for private properties to install permeable pavement would facilitate such investments by private builders and developers.

Water Audits

While our survey showed that one-third of health care facilities and over half of hotels audit their water consumption, few facilities follow this practice. Water audits are very useful to identify wastage and water losses in a home, government facility, company, industry, or other establishment. A thorough water audit analyzes a facility's water use and identifies measures to optimize its use. Audits review domestic, sanitary, landscaping, and process water use. The audits can be a service performed free of charge by a water authority and can save the owners money by reducing water consumption and its associated costs when metered. It can also save the utility money by ultimately reducing demand, and thereby preventing the need to invest in expanding the supply infrastructure. Water audits can also be conducted by the facility owner, NGOs or private contractors, and can be combined with an energy or full environmental audit to optimize potential efficiency gains. One tool available is from the American Water Works Association, which offers free water audit software at: http://www.awwa.org/files/science/WaterLoss/WaterAudit.xls. Ultimately, however, a water audit is only useful if the beneficiary implements key recommendations.

Source: Microsoft images

Water Metering and Billing and Collection

Utilities cannot effectively serve their customers if starved of financial resources. In fact, service quality suffers and water losses increase without adequate investment. In Faridabad, water metering is low, but even greater challenges stem from the exceedingly low tariffs. Non-revenue water is estimated at 52%, meaning that over half of all water collected, treated, and distributed by the utility either does not reach an end user or gets delivered but without a corresponding payment received. Faridabad will continue to lose investment by businesses and industry, and thereby erode the city's tax base, as it fails to deliver adequate water.

Universal metering of water accounts, regular and accurate reading and billing, and assertive collection on accounts are essential to city-wide water conservation and effective water management. Metering and billing are the most effective methods of sending the message of water conservation to all customer categories so that water is valued, as well as its service delivery. The most technologically advanced water metering now is automated and remotely read—"smart" meters with wireless telemetering equipment for centralized data collection. This type of metering bypasses manual readings, eliminates errors, and enables rapid feedback to customers about their water use behavior, enables early leak detection, and affords opportunities for water and cost savings.

Water Fixtures and Appliances

During site visits to the water fixture wholesale market, as well as meetings with builders and developers, it was apparent that awareness about water conserving fixtures and appliances is extremely weak. Such equipment is either not available or otherwise not easily factored into purchasing decisions, which are generally made against price and aesthetics alone. None of the fixtures sold on the market had a flow rate or discharge maximum rating, complicating consumers' ability to consider efficiency in their purchasing decisions. On one extreme, "rain shower" showerheads sold in the bathroom fixtures market are obviously highly wasteful of water. While viewed by more affluent residents as a luxury, these showerheads place an unnecessary strain upon the community's limited water supply. The survey showed that most low-income homes have zero to one WC and zero to one faucet, while middle income homes have one to three WCs and two to ten faucets per household, and high income homes have two to five WCs and six to twelve faucets. Only in the high income bracket did the survey find 19% of households with efficient dual flush toilets. By contracts, only 2% of the middle income families opted for this type of toilet. Moreover, by far the most common washing machines were the less efficient top loading varieties. Only 14% of high income and 12% of middle income families owned front loading models.

Variety of fixtures sold at wholesale market.

Photos: AIILSG

Therefore, the adoption and enforcement of standard flow fixtures and appliances would be a highly effective method of enabling long-term efficient water use in homes, businesses, hotels, institutions, etc. The difficulty in widespread adoption and use of such technology is often due to (a) relatively higher initial investment cost, (b) lack of local familiarity and resistance to change, and (c) lack of maintenance budgets and skills. A list of standard flow-rated fixtures and appliances is provided in the *National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances*, available from the California Urban Water Conservation Council (CUWCC) website at <http://www.cuwcc.org/WorkArea/showcontent.aspx?id=13966> (a few of the standards for fixtures and appliances from that source are shown in Table 10 below).

One option for the Faridabad government is to take a leadership role and retrofit government facilities with efficient technologies, such as waterless urinals, low-flow faucet aerators, recycled water for garden irrigation, etc., and provide brochures, tours, and water savings metrics that lead by example to demonstrate and publicize these approaches. In addition, apparently the Indian Plumbing Association is working with the American Plumbing Association to establish guidelines for flow rates in fixtures, and this initiative should be encouraged to improve water use optimization.

Table 10: Water Conserving Standards for Fixtures and Appliances

Fixtures / Appliances	Standard (English)	SI System
Residential or Commercial Toilets	1.6 gpf	6 Lpf
Residential or Commercial Faucets	2.2 gpm at 60 psi	8 Lpm at 4 bar
Residential or Commercial Showerheads	2.5 gpm at 80 psi	9.5 Lpm at 5.5 bar
Residential Dishwasher Water Factor (WF)	$\leq$ 6.5 gal/cycle/ft^3	$\leq$ 1.0 L/cycle/Kg
Residential or Commercial Clotheswasher WF	$\leq$ 9.5 gal/cycle/ft^3	$\leq$ 1.3 L/cycle/Kg
Commercial Urinals	1.0 gpf	4 Lpf
Pre-Rinse Spray Valve	$\leq$ 1.6 gpm	$\leq$ 6 Lpm

Note: gpf: gallons per flush; gpm: gallons per minute; WF: water factor

Public Outreach

Public awareness regarding the need to conserve water is the first step in gaining the public's cooperation to save water for the entire community. However, most end user categories demonstrated that a majority is unaware of the need for conservation. There is much room to improve, particularly since behavioral characteristics of the population with regard to water use can have a huge impact on water use efficiency. An outreach program is needed to inform the public about water conservation, its value as a vital resource, and the power of the individual citizen to have a significant impact on its conservation. Broader efforts using specialized professional firms with proven experience in public outreach programs would be highly recommended to ensure the success of campaigns promoting efficient water use. Parallel demonstration projects and stakeholder engagement by leveraging the NGO sector and universities could also help scale up water efficiency.

Modern Irrigation Methods

Based on our survey findings, hand held hose irrigation is currently quite common in Faridabad. Unfortunately, it is also inefficient, non-uniform, and results in water wastage. Some areas are over-watered, flooded, and result in runoff, while other areas remain under-irrigated. The best available technology today is drip irrigation, with many international and local suppliers and designers for small and large applications. Landscape irrigation with drip systems would save considerable volumes of water over hand watering and sprinkler systems.

Water Reclamation and Reuse Opportunities

Decentralized (Satellite) Water Recycling

Areas of Faridabad that are not currently connected to the piped sewage system would be candidates to establish decentralized water recycling systems. Each of these satellite plants would serve a cluster of homes, businesses, and institutional buildings with a collection system that would bring all wastewater to one location for treatment and disinfection—adequate for the intended use of the reclaimed water. Because of the proximity of the treatment system to points of use of the product water, only a small distribution system will be needed to bring recycled water to the points of demand. Opportunities for decentralized water recycling are abundant in Faridabad and should be studied in comparison with the centralized options. Two specific opportunities observed through the surveys and site visits in Faridabad include:

- ***Printing and Dyeing Units***
  Textile printing and dyeing units located in sectors 27, 30, 31, and 32 of the city, and each one can consume 100,000 liters of water per day. The typical facility consumes 13 to 14 liters for every meter of cotton dyed. With 65 dyeing units in Faridabad, this sector requires in the range of 5.5 million liters of water per day. Moreover, they discharge to municipal drains. This causes sewage line overflows, and negatively impacts the functioning of the sewage treatment plant due to the presence of chemicals. This also adds to the load of untreated discharge to water bodies. Currently, there is just one effluent treatment plant recycling 10,000 liters/day. Establishing a combined effluent

treatment plant and installing a sewage collection system would provide multiple benefits. A combined treatment plant by this sector will reduce the space requirements and waste treatment costs for the individual units. Furthermore, they are eligible to receive a combined subsidy from the state and national government to 50% of a treatment plant, making it more affordable. Manufacturers could also consider public-private solutions to the operation and maintenance of the plant.

- ***Decentralized Sewage Treatment and Parks Irrigation***
  Faridabad has over 450 gardens and a 67 acre golf course. A hand held hose is used to inefficiently irrigate gardens. The golf course consumes 300,000 liters of water every day, of which one-third is recycled water, treated for reuse from the neighboring area. Each garden offers the potential opportunity to establish root zone treatment or other eco-friendly options, which are less power intensive than convention treatment systems and facilitate water recycling for irrigation of the entire green area. Irrigation water can also be complemented with harvested rainwater. Efforts should also be made to expand the consumption of recycled water for irrigation. A public-private partnership model could enable investment by private parties for operation and maintenance, with revenues generated by resale of the recycled water.

Graywater Reuse

Residential graywater reuse is gaining widespread acceptance in many arid and semi-arid regions of the world (Sheikh, 2010). Because graywater is untreated wastewater—albeit excluding WC wastewater—its use for irrigation outside the house must be undertaken only with the greatest care to prevent human exposure. Authorities should develop a guide similar to the Central Public Health Engineering and Environment Organization (CPHEEO) manual, focusing on wastewater reuse, and the appropriate parameters to enable agricultural irrigation, construction activities, water for cooling towers, or flushing in water closets, as this would assist and encourage more graywater initiatives.

While graywater reuse saves water and money for the home-owner, it reduces the amount of recyclable wastewater flowing to the central treatment plant, thus reducing its treatment burden. It would be advisable for Faridabad authorities to determine which water recycling option is the most important for the community and to set policies with regard to graywater accordingly, and identify the most appropriate graywater reuse applications, such as for garden irrigation. One specific opportunity observed through the surveys and site visits in Faridabad relates to bus depot wash water:

- ***Bus Depots***
  Ballabhargh is the only bus station where buses are washed in Faridabad, and 12,000 liters/day are consumed for this purpose. About 45 buses are washed daily by hose due to malfunctioning machine washing equipment. The water supply comes from groundwater sources and purchased from water tankers. This volume of water can be recycled continuously, with only basic treatment to remove grease and dirt, saving tens of thousands of liters of water monthly.


Photo: AIILSG

Bus depot in Faridabad

Centralized Wastewater Reclamation

Water recycling from a central treatment plant is now an established practice in many metropolitan regions of the world. With appropriate levels of treatment and disinfection, this will provide increasing opportunities for use of reclaimed water for many potable uses. In the long-term, reuse of highly treated wastewater effluent, including reverse osmosis, for potable purposes will become inevitable. Potable reuse is already serving the capital city of Windhoek, Namibia. It has also been adopted in Singapore. Indirect potable reuse is practiced in the United States (Virginia's Occoquan Reservoir Augmentation, Texas' El Paso groundwater recharge, California's Orange County groundwater replenishment system, etc.). One relatively small potable reuse case in India was observed in Pune's Marigold Society, where highly treated wastewater (including reverse osmosis) is used to supplement drinking water during periods of extreme water scarcity as a way to avoid tanker truck water use with its inferior hygienic quality and higher cost.

Opportunities for Legal and Economic Instruments

While several legal and policy mechanisms are in place to encourage water conservation, policy makers should more thoughtfully consider specific instruments that will genuinely drive behavior change. This requires as much analysis regarding the type of mechanism as it does the level of incentive or penalty—otherwise customers will maintain the status quo. In this context, a special consideration for Faridabad is the poor fiscal health of the city. Incentive and penalty schemes must be designed with the understanding that Faridabad has no property tax for owners living in their own premises, and budget resources are simply not available at this time. Therefore, the city should consider innovative public-private partnership schemes, and put emphasis on revenue generation. For example, imposing fines on wasteful water use practices, or new taxes on inefficient fixtures and appliances, could generate sufficient revenue to pay more than the cost of enforcement.

One major area of consideration for officials in Haryana (and preferably, at the national level), relates to plumbing fixtures and appliances. As noted previously, even vendors of plumbing fixtures are not aware of the flow rates of the products they sell. These are purchased on the basis of aesthetics and price alone, since consumers have no information about their water efficiency. This offers many opportunities to improve water conservation:

- Labeling requirements for water fixtures and appliances can be the first step toward establishing standards for flow rates. This will begin to educate consumers and developers, and encourage vendors to stock these items. Rebates, taxes, and other economic instruments can be used to encourage or require efficient equipment, and discourage use of inefficient equipment and models, but these must be carefully designed in order to truly change behavior. As lifestyles change and appliances like washing machines become more ubiquitous, promoting water efficient appliances is very important, particularly since they tend to be more expensive. Nearly three-quarters of survey respondents have a washing machine already, and less than 11% are the efficient front loading models. Conservation campaigns, cost-based water tariffs, and higher taxes on inefficient goods will encourage more families to select efficient appliances. Similarly, studies indicate that 40 liters of the 135 Lpcd (30%) are used just for flushing toilets. The WAISP survey found that less than 7% of households have dual flush systems. Making these mandatory and providing disincentives for single flush systems, would have an important water conservation impact. Since water tariffs are so low, it may actually be the case that subsidizing dual flush toilets is less expensive than delivering the current larger volumes of water to customers.

- As noted previously, kitchen faucets generate graywater that can be reused within the household, for gardening, toilets, or in desert coolers. Technical and/or financial support to families to establish graywater reuse systems would facilitate more widespread adoption.

- Another important institutional measure would be to consider establishing a water demand management unit within the MCF. Such a unit could support municipal level conservation efforts through outreach campaigns, assist with enforcement, and engage users through technical assistance relating to fixtures, rainwater harvesting, graywater reuse, and other household or colony-level conservation initiatives.

While India lags behind other countries in introducing water efficient technologies and enacting laws making them mandatory, the country would not start from scratch. The Bureau of Indian Standards (BIS) is the premier agency in India assigned the task of developing standards, marking, quality certification, and quality control on a wide range of products and processes. A few BIS standards prescribe guidelines and certify sanitary products like cisterns, commodes, faucets, etc.[12] While BIS standards are not binding, they can serve as a starting point toward achieving such standards. The energy Standards and Labeling Program of the Ministry of Power, GoI which was launched in 2006 provides a good lesson in this regard. It currently applies to 12 appliances, four of them mandatory since January 2010.

Moreover, voluntary standards such as from green rating certification programs like the Indian Green Building Council (IGBC) Green Homes, Leadership in Energy and Environmental Design (LEED) India, and Green Rating for Integrated Habitat Assessment (GRIHA), also provide important model approaches from which to consider minimum requirements. Many opportunities, then, exist to improve water conservation through legal and policy reforms.

[12] *See*, for example, IS 774:2004 - standard for flushing cistern for water closets and urinals (non-plastic) cisterns; IS 2326:1987 - automatic flushing cisterns for urinals and IS 7231:1994 - specification for plastic flushing cisterns for water closets and urinals.

ANNEX 1: BEST PRACTICE CASE STUDIES

This section comprises a number of best practice case studies and reference materials for further review by water sector stakeholders. These cases represent examples from India and from around the world, and were selected on the basis of the relevance to the Indian context in the pursuit of urban water use efficiency.

Select Indian Case Studies

1. Pune Marigold Housing Society: Direct Potable Reuse

Location: Marigold Cooperative Housing Society is a residential housing complex of 100 high-end apartments in Pune city located in Kalyani Nagar. The society occupies approximately one-fourth of a larger property of around 46 acres, including a large decorative lake that receives runoff from surrounding areas and wastewater effluent from the building's treatment system. The rest of the area is still being developed. The housing society's area includes 10,000 m^2 of lawns and gardens.

Photo: Bahman Sheikh

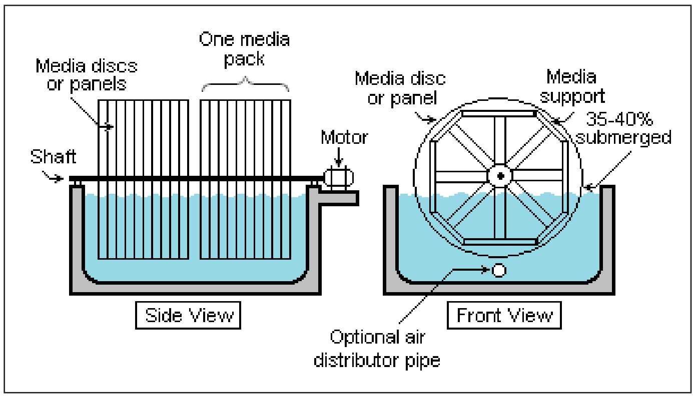
Aeration Tank

The Problem: For five years, residents of Marigold Cooperative Housing Society put up with the stink from a drain that flows along the property into a river and was a rich breeding ground for mosquitoes. The residents of Marigold Society also did not want to further pollute the river with the overflow from their septic tanks.

The Intervention: The Society decided to solve the problem by creating a bypass system for the drain first. Then they installed a system for secondary treatment for nearly 100,000 L/d of septic tank effluent using a patented “Nature-cell” rotating biological contactor (RBC) with a three hour residence time. The RBC process involves allowing the wastewater to come in contact with a biological medium in order to remove pollutants in the wastewater before discharge of the treated wastewater to the environment.

The RBC (Figure 4) consists of a large diameter steel or corrugated plastic media centered around a horizontal shaft placed in a concrete tank. The media is slowly rotated (1.5 rpm) and at any given time during the rotation about 40% of media surface area is in the waste water. Organisms in the waste water attach and multiply on the rotating media until they form a thin layer of biomass. This shaggy fixed film growth presents a very large very active population for the biological degradation of organic pollutants. During rotation, the media carries the biomass and a film of waste water into the air where oxygen is absorbed. The dissolved oxygen and organic materials in the waste water diffuse into the biomass and are metabolized. The radial and concentric passages in the media allow unrestricted entry of the waste water and air throughout the unit's total surface area for continued growth of the biomass.

Figure 4: Schematic Diagram of a Typical Rotating Biological Contractor (Reproduced from Wikipedia)



Excess biomass shears off at a steady rate as the media rotates these solids and are carried through the RBC system for subsequent removal in a conventional clarifier. The RBC process does not require recycling, and unlike the activated sludge, can withstand shock loadings or variance in volumes. This process requires only 25% of the energy cost of the activated sludge process and the quality of the sludge enables it to settle even in shallow secondary clarifiers.

Water released after secondary treatment

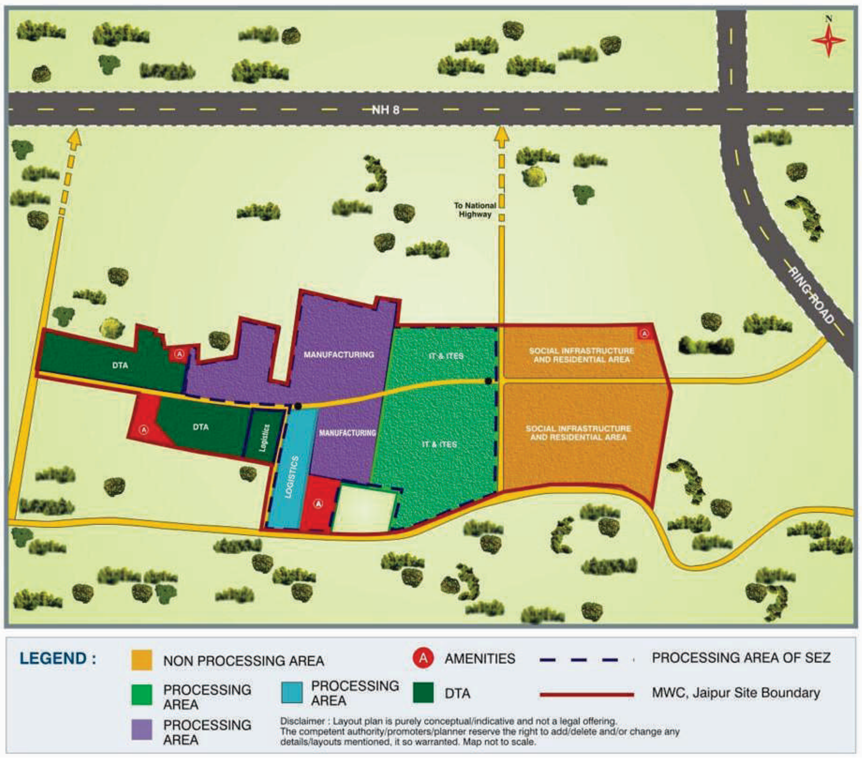
Improvements in the System: While the original intention of the residents was to prevent pollution of the river body, repeated water cuts during summers forced the residents to buy water from the commercial water tankers. The water quality of the tanker water did not meet potable standards, and mixing this water with the Municipal supply was not the solution. The residents then decided to treat their secondary treated water to the tertiary stage by membrane filtration. They opted for the 100 picometer (Polymecide Membrane) membrane which has a pore size 150 times smaller than the smallest E. coli. New Water Singapore uses a 15 pico membrane which has a pore size only 100 times smaller than the smallest E. coli. The reverse osmosis unit can treat 3000 liters per hour and the treated water then passes through an ultraviolet (UV) unit and is chlorinated prior to storage. The Society has carried out repeated testing of the treated water which meets potable standards and is currently seeking permission from Pune Municipal Corporation to use it for potable purposes.

This type of water recycling uses the most advanced practice and best technology available world-wide—emulating similar technologies currently in use in Singapore, Australia, and the United States (Orange County Groundwater Replenishment System in California, Occoquan reservoir augmentation in Virginia, City of El Paso, Texas, and others). It is anticipated that in the future, more critical water shortages will make adoption of this type of water recycling on a large scale a viable option.

Photos: Bahman Sheikh

Membrane filters for tertiary treatment

2. Mahindra World City (Special Economic Zone), Jaipur



Layout of Mahindra World City. Source: MWC publication.

Location: Mahindra World City (MWC), Jaipur is the largest public-private partnership project in Rajasthan, and is expected to create large scale industrial development and employment[13] in the state. It is a 74% / 26% joint venture between Mahindra group firm *Mahindra Lifespaces* and Rajasthan Industrial and Investment Corporation (RIICO). The total project area is 3,000 acres, which is demarcated as Special Economic Zone (SEZ) under the SEZ Act of Government of India (2005). The multi-product SEZ will have three zones: IT (750 acres), light engineering, including auto and auto component (250 acres), handicraft (250 acres), besides zones for apparel, gems and jewelry, logistics and warehousing. A domestic tariff area for ancillaries to support export units and 714 acres of residential and social infrastructure has also been earmarked. At the time of report, approximately one-third (1,000 acres) have been developed and 41 industries have invested in the project. The project is located approximately 20 kilometers away from the centre of Jaipur city.

Mahindra Group's Eco-friendly Philosophy: The Mahindra group has a stated policy of adopting ecologically sound principles of sustainable growth. A group publication titled “Sustainability Review” (2011) states their commitment to contribute to the national goal of combating climate change by aligning their operations with the National Action Plan on Climate Change (NAPCC). Mahindra Group has also made it a point to embed green features in all new building projects. It has retrofitted its office in Mumbai (Mahindra Towers) to ensure that it is energy-efficient. Mahindra World City (MWC) has developed an in-house team of engineers and architects as certified energy saving analysts. The Management Development Centre of the Mahindra Group at Nasik, Maharashtra

[13] Twenty companies have signed up for these zones, who will invest more than Rs 1,000 crore, employ 75,000 people and generate exports of Rs 35 billion within four years.

has adopted rainwater harvesting technology and converted all existing urinals into “waterless urinals” using bio-blocks. Water audits are carried out in all its Divisions.

As a part of its sustainability road map it sets very clear targets for reducing resource consumption. The target for 2012 was reduction of energy use by 2% against which the various Divisions had achieved 7.8% reduction as per the above energy audit report. The group reports special projects which have adopted the 3R (Reduce / Reuse / Recycle) methodology for reduction in specific water consumption and packaging waste. The MWC is one such project.

Photo: Dipak Roy

Sprinklers in the nursery

Water Use Practices in MWC: The SEZ project, when fully operational, will meet two-thirds of its water needs by using recycled water for all non-drinking usage. It will recycle its water as well as take treated sewage water from Jaipur and use it after tertiary treatment. The project has committed to adopt the following practices during the construction phase as per the communication from State Level Environment Impact Assessment Authority, Rajasthan:[14]

Construction Phase:

- Storm water control and its reuse as per CGWB and BIS standards for various applications
- Water demand during construction reduced by the use of pre-mixed concrete, curing agents and other best practices
- Separation of grey and black water done by the use of dual plumping line for separation of grey and black water.
- Treatment of 100% grey water by decentralized treatment
- Fixtures for showers, toilet flushing and drinking shall be of low flow either by use of aerators or pressure reducing devices or sensor-based controls

Operation Phase:

Rain water harvesting for roof run-off and surface run-off to be complied as per GoI guidelines. Before recharging, surface run-off to be pre-treated to remove suspended matter, oil and grease.

[14] Letter dated 18 Nov 2010 from Rajasthan State EIA Authority on environmental clearance as per EIA Notification, 2006)

Work in Progress: As mentioned earlier, only one-third of the project area has been developed thus far. Therefore, this is very much work in progress. The Public Health Engineering Department (PHED) of Government of Rajasthan was to install the pipeline from the Sewerage Treatment Plant at Delawas (nearly 20 km away) for carrying treated sewerage water for reuse. However, the PHED has not been able to meet its commitment because no provision was made in its budget. In March 2011, it was finally decided that RIICO as a partner would provide the budget while PHED would lay the pipeline. The work is yet to be completed.

Reduction of potable water consumption is being considered by the MWC through the use of grey water from Central Sewage Treatment Plant for flushing and landscaping, low flow water faucets within the homes, rainwater/storm water management system and use of Xeriscape[15] in Landscape (so that the landscape will be drought tolerant and will consumes less water). Water saving is also done with the use of timer-based water sprinklers, drip irrigation system, moisture sensors, pressure regulating devices for water control and water meters etc.

Validation by Independent Agencies: The University of West Minister has conducted an International Eco-City Initiative: Global Eco City Survey in 2011, which includes the MWC in its profile (Joss, 2011). Because of all the efforts that it has made, Mahindra World City, Jaipur, has been identified as one of 16 projects globally, which are being supported by the Clinton Climate Initiative (CCI), a foundation for sustainable development promoted by former US President Bill Clinton.

3. Case Study in Lake Restoration with Private Participation: Man Sagar Lake, Jaipur, India

Introduction: Man Sagar Lake was created as an artificial lake in the 16th Century during the Moghul period, by Raja Man Singh of Amber. He erected a dam 700 meters long, 40 meters wide, and 15 meters high south-east of Amber. In 1727 Jaipur was established as a planned city on the periphery of Amber, and the southern fringe of the lake. Its ruler, Maharaja Sawai Pratap Singh, built a palace garden for entertainment in the middle of the lake during the 18th Century. It was called Jal Mahal, which literally means “Palace on water”. The lake would receive water from the adjoining hills as well as the city.

[15] A landscaping approach that incorporates water conservation techniques, such as low water consuming plants and vegetation, efficient irrigation methods, decorative hard surfaces, etc.

The area of the lake has been estimated between 310[16] acres and 343[17] acres by different sources. The average depth of the lake was reported to range between 2.18 meters during peak monsoon to 1.62[18] meters during the dry season, before any interventions took place in the 1990s. Two main drains carry water from the drainage area which includes the adjoining Nahargarh hills as well as the city area: I) the Bramhapuri Nalla coming from the north-western flank of Jaipur city and entering into the southern region of the lake, and ii) the Nagtalai Nalla, coming from the eastern region of the city and entering into the south-eastern region of the lake. The catchment of the lake has been estimated to be around 23.5 sq km, of which approximately 40% is constituted of urban area, while the north-western hill slopes constitute the remaining area.


Photo: Down to Earth

Man Sagar Lake before intervention

Challenge: As the city grew, water quality in the lake began to deteriorate. City authorities diverted most of the city's raw sewage to the lake in the 1960s, along with nearly half of the city's run-off. As a result, the lake became silt rich with a heavy organic load, which only grew with the city's population. Eventually, solid waste generated in the city was also dumped into the lake, and by the 1990s, there was very little water during the year except during the monsoon months. During the rest of the year, since the lake was mostly dry, it was used as an open defection ground, for grazing animals, and partly as a play ground by children.

The Bramhapuri Nalla releases about 30 MLD of sewage daily, which is now treated in a sewage treatment plant (STP) built by the Jaipur Municipal Corporation (JMC) in year 2007-2008. However, the capacity of this plant is 27 MLD, which means a part of the sewage flows untreated. The Nagtalai Nalla currently releases about 8 MLD into the lake, all of it untreated sewage.

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[16] This was reported in the Detailed Project Report prepared by PDCOR – an infrastructure project development company jointly promoted by Government of Rajasthan (GoR) and Infrastructure Leasing and Finance Services Limited (IL&FS) which was commissioned by the Tourism Department of GoR to prepare a tourism project on the site.

[17] Maximum spread during monsoon in report by Bharat Lal Seth in "Down to Earth", 15 September 2012

[18] Central Pollution Control Board, 2003.

Restoration Approach: As far back as the 1980s, the Government of Rajasthan (GoR) had earmarked the land around the lake for tourism development in its Master Plan. During the late 1990s, the Tourism department of GoR engaged PDCOR Limited,[19] to prepare proposals for tourism development projects in Rajasthan. PDCOR developed one such proposal with a focus on the Man Sagar Lake. A number of plans were made to rejuvenate the lake until about 2000; however, these were unsuccessful due to a paucity of funds and the lack of incentives to undertake restorations (CSE). In 2002 the Ministry of Environment and Forests (MoEF) within the Government of India (GoI) prioritized the task of restoring the lake under the National Lake Conservation Plan. The MoEF identified the Jaipur Development Authority (JDA) as the nodal agency for the task and sanctioned a budget of Rs 247.2 Million for the project. The GoI share was Rs 173 million in this budget, while GoR was to contribute the remainder.

Photo: Down to Earth

Man Sagar Lake after rehabilitation

This commitment from GoI enabled decisive advances in the restoration effort. Among them, the Sewerage Treatment Plant serving the Bramhapuri Nalla was upgraded. (The Nagtalai Nalla sewage is diverted into artificial wetland treatment system). In addition, a two kilometer tourist trail was built as well as a one kilometer-long promenade. Even so, the budget provided under the National Lake Conservation Plan was insufficient to undertake a more comprehensive plan for developing the area and assure long-term operation and maintenance. Therefore, a tender was released in 2004 to engage private participation in response to which four consortia submitted bids. The project was awarded to Jal Mahal Resorts Private Limited (JMRPL), led by Kothari Builders, giving them a 99 year lease agreement at an agreed annual lease amount of Rs. 25.2 million, with a built-in provision for 10% increase every three years. "The objective behind private sector participation was to ensure funds to operate and maintain the pollution abatement infrastructure" (Seth, 2012).

[19] PDCOR is a company jointly promoted by the GoR and private sector to facilitate infrastructure investments in Rajasthan.


Photo: Bahman Sheikh

Newly laid garden in the center of the restored monument

Results: The following summarizes the interventions undertaken to improve the quantity and quality of water in the lake and improve the habitat, and the corresponding results.

1. The lake bed has been dredged to a depth of 3 to 3.5 meters in 2008, as a result of which the water holding capacity of the lake has increased.

2. Both of the main drains into the lake (Bramhapuri and Nagtalai) have been by-passed by creating a new masonry drain of approximately 1.5 km, so that sewage cannot flow directly into the lake.

3. The STP run by the JMC with a capacity of 27 MLD which uses extended aeration technology has been upgraded. In addition, a Tertiary Treatment Plant (TTP) has been established by the JDA close to the STP, with a capacity of 7.8 MLD.

4. At three locations, JMRPL created 21 enclosures of constructed wetlands, covering an area of 40,000 m^2, providing further, natural treatment of the water coming out of the STP/TTP before discharging to the lake.

5. The storm water that enters the lake (estimated 7,050 million liters per annum) is estimated to carry about 200 tons of silt into the lake annually. The suspended load in the water entering the two *nallas* is calculated at 100 milligrams per liter and is constituted of both organic and inorganic material. JMPRL has created a sedimentation basin within the lake below the embankment where nearly 60% of this silt gets trapped, thus substantially reducing the silt load in the lake.

6. The improved water holding capacity of the lake, combined with the treated wastewater discharged, has turned the Man Sagar Lake into a perennial water body.

7. Selected aquatic vegetation has been introduced from the same region (Keoladeo National Park at Bharatpur) for beautification and to ensure that pollutants get absorbed.

8. As a result of the interventions, the water quality has reportedly improved substantially: In July 2005 and 2006 when the MoEF tested the water quality for biochemical oxygen demand (BOD), it was in the range of 115 to 210[20] milligrams per liter, well over the standard for quality of water for bathing. After interventions, the water quality has been recorded with a BOD of less than 30 mg/liter, the stipulated discharge norm as per the Central Pollution Control Board.

[20] Data on water quality improvement have been reproduced from “Down to Earth” CSE Webnet of 15 September 2012 (Author: Bharat Lal Seth).

In conclusion, the restoration of the Jal Mahal Project provides an example of a potentially effective public-private partnership for water reuse, improved wastewater treatment, as well as tourism development. Importantly, it provides a revenue model to ensure long-term maintenance. The lease itself, however, is under litigation within the Indian Supreme Court, where the scope of restoration vs. what could be defined as new construction is in dispute. Notwithstanding this situation, the model has proved effective in accomplishing the above noted results.

International Case Study References

1. Australian Water Savings Experience during an 11-Year Drought

During the years 1998-2010, Australia underwent a severe sustained period of drought, considered to be a harbinger of global climate change. Water supplies were so stressed that one state, New South Wales built a huge direct potable reuse system. All over the country, communities adopted water conservation measures in all water using sectors. Overall residential water use dropped from 315 Lpcd to 213 Lpcd over the nine-year period 2000 to 2009 (Cahill et al., 2011). This impressive (>30% percent) reduction in per capita water use was achieved with a nation-wide campaign of water conservation behavior change and institutional revisions in how water was managed. Three actions contributing to Australia's reduced water use are (1) adoption of outdoor water restrictions, (2) ultra-low flush WCs, and (3) water pricing policies. Another important factor in the conservation effort's success is tracking water use with accurate, quantitative data. This enables the communities to document and therefore manage water use according to goals and what the data indicates about progress toward those goals.

2. United States Department of Housing and Urban Development Water Conservation Benchmarking Tool

The United States Department of Housing and Urban Development (USHUD) developed a useful benchmarking tool for residential buildings to compare their water conservation efforts against established benchmarks as a means of monitoring progress and measuring success along the way to achieve their desired conservation goals. In order to develop the water consumption benchmarking tool, water consumption data was collected through voluntary release of information from thousands of buildings in nearly 350 public housing units nationwide. Regression analyses were performed on these datasets to see which of over 30 characteristics were most closely linked to water conservation. The benchmarking models were then developed by quantifying the effects of the building traits that most commonly correlated with water utilization. The benchmarking tool that resulted from this exercise is Excel-based and quite adaptable to various types of buildings for assessment of their water use characteristics and determination of best practices to reduce water demand. The Excel-based tool can be downloaded from: http://portal.hud.gov/hudportal/documents/huddoc?id=DOC_26031.xls

3. California Urban Water Conservation Council

California's climate and water supply characteristics are similar to Rajasthan's, although there are vast differences in demographic and other characteristics. Over the last 25 years, the California Urban Water Conservation Council (CUWCC) has worked closely with water authorities throughout the State of California for adoption of Best Management Practices (BMPs), each of which is designed for a specific action with an implementation path to reduce water demand. Over this period, residential water demand has dropped by ten percent—not as impressive as the Australian case, but significant with room for greater progress in the future. Much can be learned from this experience and the tools made available by CUWCC. Most of these experiences and technical resources are available on the website of the Council: http://www.cuwcc.org/

4. California Best Management Practices

In the early 1990s, a large number of retail water providers in the State of California in the United States signed agreements among themselves committing to water demand reductions using the most effective water conservation methods available. The list of these water conservation BMPs include:

1. Water survey programs for single-family residential and multi-family residential customers
2. Residential plumbing retrofit
3. System water audits, leak detection and repair
4. Metering with commodity rates for all new connections and retrofit of existing connections
5. Large landscape conservation programs and incentives
6. High-efficiency clothes washing machine financial incentive programs
7. Public information programs
8. School education programs
9. Conservation programs for commercial, industrial, and institutional (CII) accounts
10. Wholesale agency assistance programs
11. Retail conservation pricing
12. Conservation coordinator
13. Water waste prohibition
14. Residential ultra low flush toilet (ULFT) replacement programs

Over the last 21 years, these BMPs have been refined and have borne fruit so that water use levels have declined or remained unchanged in spite of significant population increases in the service areas of the BMP signatories. Detailed implementation and monitoring protocols for each of these 14 BMPs is available at the website of the California Urban Water Conservation Council: http://www.cuwcc.org/bmps.aspx?ekmensel=b86195de_24_0_7794_2

Photo: Bahman Sheikh

Automatic sprinkler system in use

5. Water Saver Home

The CUWCC has developed a useful tool for the homeowner to inventory their own water use characteristics and compare them with best practices for water conservation and to make effective changes for water (and money) savings is the H2OUSE—Water Saver Home, accessed at: http://www.h2ouse.org/. An example, showing the benefit of a simple lawn sprinkler water use audit, from one of the many water savings tips in this website follows:

An automatic sprinkler system is almost always the largest user of water. If you're looking for a way to save water it makes sense to focus on the big uses. It doesn't get any bigger than the sprinkler system.

From a horticultural standpoint, over-irrigation occurs much too often. However, it is most prevalent in the cooler fall months when summer irrigation schedules have not been revised to meet the current weather conditions. Over-irrigation causes three basic problems; it:

- pushes water beyond the root zone and is wasted. This occurs most notably in the case of turf grass.

- causes excessive run-off, which contributes to non-point source environmental pollution.

- generally degrades plant health.

There are a number of ways to reduce outdoor water use and automatic irrigation and all of these recommendations are explored in great detail in this web site.

Saving water outdoors depends on a number of factors including the type of plant material, the soil, landscaping practices, climate, irrigation system efficiency, etc. It can all be a bit overwhelming. Many water utilities offer free landscape audits. An audit is a great opportunity to meet with a local expert and discuss ways to improve efficiency on your specific landscape.

6. East Bay Municipal Water District's Watersmart Guidebook
East Bay Municipal Water District (EBMUD) is a retail water and sewerage provider for a large population on the eastern side of San Francisco Bay in California, USA. This water authority is one of the most aggressive in the United States in promoting water conservation. In 2008, EBMUD prepared and published a highly practical publication, entitled “Watersmart Guidebook”, with 242 pages of text, graphics, photos and charts providing its new business customers and their consultants with a wealth of up-to-date material for saving water. While the guidebook is primarily intended for new businesses seeking approvals within the EBMUD service area, the guidebook can assist other water agencies wanting to emulate similar approaches to water savings. The guidebook is freely available to anyone at: http://ebmud.com/for-customers/conservation-rebates-and-services/commercial/watersmart-guidebook.

Examples of Regulations Advancing Water Efficient Technologies and Labeling

The following section provides some international examples of regulations that promote the adoption and implementation of water efficient technologies, as well as recommended general best practice measures.

- **United States:** The Energy Policy Act of 1992 (Public Law 102-486) *inter alia* addresses water efficiency on a national scale and mandates the use of water-efficient fixtures. It is mandatory for new buildings to install domestic water efficient devices, and regulations define maximum water use standards for plumbing fixtures. In January 2008, Congress enacted new laws to limit the water use of dishwashers and washing machines.

  As part of the U.S. government's goal to lead the nation by example in improving energy and water efficiency, Executive Order 13123, Greening the Government through Efficient Energy Management (1999), directs government agencies to reduce their potable water consumption. This order calls on the government to implement all cost-effective water conservation measures in Federal facilities by 2010. The order also required Federal agencies to determine their baseline water use in fiscal year 2000, and report on their usage every two years. Agencies must also implement at least four of 10 cost-effective Best Management Practices (BMPs) for water conservation at up to 80 percent of their facilities by 2010.

- **Australia:** All Australian states have regulations relating to dual flush and low volume toilets for new houses and replacement products, and the same for aerators and flow regulators for showerheads and kitchen faucets. Suppliers are now under pressure to adopt a subsidized retrofit scheme for the installed base of old style single flush toilets, as is done in various states and cities in the United States.

- **United Kingdom:** Following amendments to Part G of Building Regulations, from 6 April 2010, all new homes will have to meet a water efficiency standard of 125 liters of water per person per day. The government has also introduced an Enhanced Capital Allowance (ECA) scheme for water efficient plants and machinery.

Labeling water efficient fixtures enables consumers to make informed choices on the water efficiency of a product when purchasing. It also helps to raise public awareness regarding water conservation and encourages more water efficient products on the market, and saves money over time when water is priced and billed properly. Several countries have well-established schemes to label water efficient fixtures and services.

- **United States:** WaterSense (http://www.epa.gov/watersense/) is a voluntary partnership program by the United States Environment Protection Agency (USEPA) with various companies, which was launched in June 2006, and is designed to encourage water efficiency in the country. WaterSense labeled products meet EPA's specifications for water efficiency and performance and are typically about 20 percent more water efficient compared to corresponding conventional products. WaterSense has many resources available, including the National Efficiency Standards and Specifications for Residential and Commercial Water-Using Fixtures and Appliances, available at: http://www.epa.gov/WaterSense/docs/matrix508.pdf

- **Australia:** The national government's Water Efficiency Labeling and Standards (WELS) Scheme is responsible for the WELS water efficiency star ratings on products. The Smart Approved WaterMark is another simple identification label, which is applied to water efficient outdoor products in order to assist consumers to make informed choices.

- **New Zealand:** The water efficiency labeling regulations are modeled on the Australian WELS scheme. However, unlike the Australian scheme, there is no government mandated registration scheme and no minimum performance requirements are imposed.

- **United Kingdom:** The Bathroom Manufacturers Association (BMA), a leading trade association for manufacturers of bathroom products, promotes Water Efficient Product Labeling.

- **Singapore:** In 2006, the Public Utilities Board (PUB), the national water agency, introduced the Water Efficiency Labeling Scheme (WELS), a voluntary program, which covers faucets, showerheads, dual flush low capacity flushing cisterns, urinals and urinal flush valves, as well as clothes washing machines. The scheme became mandatory for water fixtures in July 2009.

- **China:** There are no federal laws that set standards for plumbing equipment. However, large cities such as Beijing, Tianjin and Shanghai have taken measures to promote domestic water saving, including subsidizing water-saving faucets or toilets and establishing education programs.

- **Israel:** The Water Authority has announced further measures to reduce water consumption, including the distribution of 1.2 million household devices to reduce the flow of water from faucets. It plans to issue a tender for the purchase and distribution of the devices, which are currently mandatory only in new buildings.

Reference Examples of Water Reclamation and Reuse

Aertgeerts, R., & Angelakis, A. (Eds). (2003).
State of the Art Report: Health risks in aquifer recharge using reclaimed water.
Geneva, World Health Organization.
Retrieved from: http://whqlibdoc.who.int/hq/2003/who_sde_wsh_03.08.pdf

As competing demands place pressures on water supplies in India and elsewhere, a body of literature has developed around experiences and projects built to recharge depleted aquifers with treated municipal wastewater. The World Health Organization's *State of the Art Report: Health Risks in Aquifer Recharge Using Reclaimed Water* examines the many facets associated with safe groundwater recharge with reclaimed water. Importantly, these guidelines include regulatory considerations to safeguard public health, an examination of the range of treatment levels and options prior to aquifer recharge, methods to assess health risks, and public perceptions and outreach strategy considerations to assure public acceptability. Moreover, the document includes case histories, including an example of soil aquifer treatment in Morocco for aquifer recharge, as well as an example of advanced wastewater treatment prior to groundwater recharge in the United States.

Brown, C. (2000).
***Water conservation in the professional car wash industry.* United States, International Car Wash Association.**
Retrieved from: http://www.carwash.org/docs/default-document-library/water-conservation-in-the-professional-car-wash-industry-.pdf?sfvrsn=0

Following water use restrictions imposed in eastern United States during the summer of 1999, the International Car Wash Association commissioned a survey of conservation techniques used in the car wash industry and constituted a think tank of industry experts to examine the means for designing water efficiency standards and advance policy discussion on water conservation and reclamation in the industry. The report finds significant saving in water use in professional car washes where conversation equipment, including a reclaim system is used. The needs of the car wash operator –conserve water, reduce discharge, meet regulatory requirements, or some combination thereof – dictate the selection of the installed reclaim system. The report includes a list of steps developed by industry associations for use by professional car washes during droughts and water shortages. The report also discusses cost components for retrofitting existing car washes. Moreover the document highlights two programs developed through industry and utility cooperation to promote water conservation, and with applicability in other locations: the Conservation Certification Program developed by the San Antonio Water System, Texas, together with the Southwest Carwash Association. And the Seattle Public Utilities, Washington, conservation grants to professional car wash operators to install reclaim systems at their facilities. These examples will be of interest to decision makers at municipalities and utilities. This document presents an example of how industry groups can get in front of policy discussions on water conservation and reclaim, to represent the interests of their constituents.

Bryck, J., Prasad, R., Lindley, T., Davis, S., Carpenter, G. (2008). ***National database of water reuse facilities summary report*. United States, WateReuse Foundation.**
Retrieved from: http://www.watereuse.org/files/s/docs/02-004-01.pdf

This project reports presents the design and management of a national database of reuse facilities, using a web-enabled application. Intended for use by water practitioners, the database was developed to advance the implementation and disseminate information on water reuse. The report details each step of the database design process: developing the survey instrument, designing and beta testing the web-enabled database, collecting state data on utilities, reaching out to state water utilities to complete the online survey to populate the database, producing reports, installing the final database application on a server for continual use. The report includes as annexures, a copy of the survey instrument, as well as, examples of two standard reports that the database produces: a summary of utility and reclaimed water facility, and a summary of reclaimed water use by end use category. This document is useful reference for national and state agencies that plan to develop relational databases for water utilities.

Department of Water Affairs. (2010).
***Strategy and Guideline Development for National Groundwater Planning Requirements. The Atlantis Water Resource Management Scheme: 30 Years of Artificial Groundwater Recharge*. P RSA 000/00/11609/10-Activity 17 (ARS.1). Republic of South Africa.**
Retrieved from: http://www.artificialrecharge.co.za/casestudies/Atlantis_final_10August2010_reduced%20dpi.pdf

This report produced by the Department of Water Affairs, Republic of South Africa, provides information about the Atlantis Water Resource Management scheme for the planned town of Atlantis (now a part of the metropolitan area of Cape Town), South Africa. The scheme, which evolved over a 30 year period, diverts treated domestic effluent and domestic storm water to two infiltration basins up-gradient of well fields to recharge the aquifer. From here it is abstracted and recycled for municipal use. The scheme diverts industrial effluent and industrial storm water to the coast down-gradient of the main aquifer to coastal recharge basins to raise the water table and prevent seawater intrusion. The report tracks the evolution of the scheme from its inception during the town planning stage in 1970, to the integrated scheme as it now exists. The report documents the efforts of engineers and scientists to design the integrated scheme, including technical and operational issues addressed over time. Finally the report draws lessons from the thirty years of operations, management and monitoring and makes recommendations for the need for integrated management to ensure the scheme's long- term sustainability. This report is useful reference for engineering and scientists to understand technical, operational and management challenges associated with the development and operations of an integrated water resources management system.

Economic Analysis Task Force for Water Recycling in California. (2011). Guidelines *for Preparing Economic Analysis for Water Recycling Projects.* California, State Water Resources Control Board.
Retrieved from:
http://www.swrcb.ca.gov/water_issues/programs/grants_loans/water_recycling/docs/econ_tskfrce/eagd.pdf

This document produced by the California State Water Resources Control Board provides guidance on conducting economic and financial analysis of water recycling projects. The guidance considers water recycling as a part of integrated resources management and recommends that planners, utilities and local governments begin by establishing baseline forecasts of land use, population, institutional, legal and other requirements; and establish clear water supply objectives and alternatives prior to the analysis. Economic analysis considers and quantifies societal cost and benefits of a project over a selected time horizon. Risk and sensitivity analysis form part of the economic analysis and quantify the effect of uncertainties in parameters and events. A financial analysis emphasizes the financial viability of a project and its ability to generate sufficient revenues to cover construction and operations costs. Such costs may be allocated across purposes and beneficiaries. The analysis is useful for designing capital financing mechanisms, estimating debt service requirements for a portfolio of funding sources, and identifying need for additional leverage. This document is a useful template for utilities and cities on how to work through an economic and financial analysis for a water recycling facility. Such analysis may be used for applying for grants and loans, as well as for evaluating alternatives for recycling projects.

Environment and Natural Resources Committee. (2009).
***Inquiry into Melbourne's Future Water Supply.* Australia, Parliament of Victoria, Paper No. 174 Session 2006-2009.**
Retrieved from: http://www.watereuse.org/files/images/Inquiry_into_Melbourne_s_Future_Water_0609.pdf

The Victorian Parliamentary Environment and Natural Resources Committee, constituted under the Parliamentary Committees Act 2003, as amended, produced this parliamentary report on the merits of supplementing Melbourne's water supply. Amongst other findings, the report recommends: mandating simple low cost water efficient fixtures; establishing an environmental sustainability assessment and rating system that includes water use efficiency and conservation; revising planning provisions and building regulations to promote storm water harvesting; and, setting and enforcing new recycling and reuse targets for treated wastewater. The committee also recommends that a groundwater management strategy be developed. This parliamentary report serves as an example for policy makers in India and other countries on undertaking a comprehensive assessment of a water supply system, vis-à-vis options to supplement water supply; and to deliberate and translate findings into actionable policy directives.

Environment Protection and Heritage Council (EPHC), Natural Resource Management Ministerial Council (NRMMC), & Australian Health Ministers' Conference (AHMC). (2006).
***Australian Guidelines For Water Recycling: Managing Health and Environmental Risks (Phase 1).* Retrieved from:**
http://www.scew.gov.au/archive/water/pubs/wq_agwr_gl__managing_health_environmental_risks_phase1_final_200611.pdf

Produced by the Environment Protection and Heritage Council, Natural Resource Management Ministerial Council, and Australian Health Ministers' Conference; these Australian guidelines on water recycling address—safe and sustainable—supply, use and regulation of recycled water schemes. These comprehensive national guidelines provide a consistent approach across Australian state and territory governments, and are intended to be implemented in collaboration with relevant health and environment authorities. The guidelines present a risk management framework that emphasizes management of recycled water schemes, as compared to simply using post-treatment testing. The framework recommends an analysis of health and environmental hazards, and critical control points, so as to undertake preventive measures that reduce risks to an acceptable low level. The elements of the risk management framework are grouped under the following categories: commitment to responsible use and management of recycled water; system analysis and management; supporting requirements (employee training, community, research and development, documentation and reporting); review (evaluation and audit). The document discusses risks from the use of water recycling from a sewage treatment plant and from graywater, and characterizes both maximum as well as residual risk. Preventive measures to reduce risk include treatment processes and reduced exposure, either by using at the site of use or restricting use. Monitoring establishes baselines, and is needed to validate systems and operations. Validation of system effectiveness is essential because of the potential health risks associated with recycled water. The risk management framework emphasizes consultations and communication, to ensure stakeholder support. The document includes case studies of recycling of treated water from sewage treatment plants for irrigation of commercial crop, golf courses, municipal landscaped areas; and, on the use of graywater in toilet flushing and outdoor uses. Policy makers in India and other countries will find the risk management framework presented in these guidelines as useful reference for developing similar approaches for water recycling schemes, to address health and environmental risks.

Federal Energy Management Program. (2011). ***Methodology for Use of Reclaimed Water at Federal Locations.*** **U.S. Department of Energy. Retrieved from:** http://www1.eere.energy.gov/femp/pdfs/reclaimed_water_use.pdf

The U.S. Federal Government requires reduction of water consumption at Federal sites and under Executive Order 13514 directs Federal agencies to implement water reuse strategies consistent with state laws that reduce water consumption. This fact sheet, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information to Federal agencies on the process of initiating a water reuse project using reclaimed water. This fact sheet distills information from the 2004 EPA Guidelines for Water Reuse, to identify six key steps: (i) Understand state laws and contact state regulatory agencies. The use of reclaimed wastewater in the U.S. is regulated by state and local laws, and varies across states. (ii) Classify project type, to determine necessary water quality standards and treatment options; (iii) decide whether to purchase reclaimed water from local municipal wastewater treatment plant or produce reclaimed water on-site, based upon considerations such as conveying costs, population, reuse purpose and quantity required, etc.; (iv) secure permits; (v) work with an experienced contractor; and, (vi) communicate and educate people that will be exposed to the system. The fact sheet also includes two brief case studies of water reclamation projects at Federal facilities. This fact sheet would be a handy reference for staff at government facilities on the steps involved in starting a water reuse project.

Federal Energy Management Program. (2011).
***NASA's Marshall Space Flight Center saves water with high efficiency toilet and urinal program: BMP 6 – toilets and urinals.* U.S. Department of Energy.**
Retrieved from:
http://www1.eere.energy.gov/femp/pdfs/nasa-msfc_watercs1_.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the success of a water efficiency program that included the development and installation of innovative high-efficiency toilet and urinal fixtures, at NASA's Marshall Space Flight Center (MSFC). High-efficiency fixtures are fixtures that exceed the current standards for toilets and urinals as set under the Energy Policy Act of 1992. The facility engineering team examined performance and operating standards of high-efficiency fixtures, together with the operational constraints related to replacement at the aged building, to develop tailored design specifications suited to the facility's old fragile plumbing. The team then tested these innovative high-efficiency fixtures at a demonstration project and measured results. MSFC is now retrofitting these high-efficiency fixtures at identified buildings across the flight center. The MSFC water efficiency program comprises: water metering, leak detection and repair, water management of cooling towers, water reuse for limited irrigation, native landscaping, and staff outreach. This case study demonstrates the successful use of innovative high-efficiency fixtures for replacement at a Federal facility with aging infrastructure.

Federal Energy Management Program. (2009).
***Huntington Veterans Affairs Medical Center: BMP 7 - faucets and showerheads.* U.S. Department of Energy.**
Retrieved from:
http://www1.eere.energy.gov/femp/pdfs/huntingtonva_watercs.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the performance and economics of a water efficiency program that retrofit 178 faucets and 33 showerheads at the Huntington Veterans Affairs (VA) Medical Center in 2007. The medical center used in-house staff to replace the old faucets and showerheads with newer, water efficient models, which incorporated antimicrobial technology. These improvements save the medical center more than 1.5 million gallons of water each year. In addition the medical center also converted 87 toilets with water efficient, dual flush toilets. This case is an example of the water savings that can be achieved through the use of new, improved fixtures in buildings.

Federal Energy Management Program. (2009).
Water reclamation and reuse at Fort Carson: BMP 14 – alternate water sources. **U.S. Department of Energy.**
Retrieved from: http://www1.eere.energy.gov/femp/pdfs/water_fortcarson.pdf

This best management practice case study, produced under the Federal Energy Management Program of the U.S. Department of Energy, provides information about the performance, economics and success of a water conservation program comprising water reclamation and reuse at the U.S. Army's Fort Carson. For over three decades, the base has used treated effluent from its wastewater treatment plant, to irrigate 180 acres of their golf course. Effluent is also reused as process water required in the operations of the wastewater treatment plant. In addition, over the past two decades, the base has successfully operated a vehicle wash facility that uses recycled water through a closed loop system. Through this water conservation program, the base saves approximately 303 million gallons of water annually. This case study demonstrates the potential for municipalities in India and elsewhere for water and cost savings through water reclamation and reuse.

Golf Course Superintendents Association of America (GCSAA) and The Environmental Institute for Golf (EIFG). (2009).
Golf Course Environmental Profile, Volume II, Water Use and Conservation Practices in U.S. Golf Courses. **GCSAA.**
Retrieved from:
http://www.gcsaa.org/_common/templates/course/environment/EnvironmentLandingPageLayout.aspx?id=3544

This report produced by the golf course industry in the U.S. presents findings from a survey of over 2500 golf courses in the U.S. on water use and conservation practices. This survey was intended to establish a baseline for comparison with future findings. While the survey identified no difference between private and public golf course in the use of recycled water, it found that a higher number of the larger courses with higher maintenance budgets, used recycled water for irrigation. This report is an example of the role industry groups can play in promoting water use and conservation at their facilities.

Koeller, J. & Brown, C. (2006).
Evaluation of potential best management practices: Vehicle Wash Systems.
California, California Urban Water Conservation Council.
Retrieved from the CUWCC website: http://www.cuwcc.org/products/pbmp-reports.aspx

This report published by the California Urban Water Conservation Council provides an evaluation of a range of water savings practices in vehicle wash systems within the State of California. The study starts by examining water savings opportunity in different vehicle wash systems: conveyor carwashes; in-bay carwashes; self-service carwashes; and truck, bus and fleet washes. This is followed by a technical discussion of water reclaim and conservation practices and processes, used by businesses during each step of the operation of the different vehicle wash systems. Of particular interest to decision makers at municipalities and utilities in India and elsewhere, will be the discussion of approaches, such as, carwash business certification by utilities, and the use of municipal ordinances and state regulations on vehicle wash businesses to achieve water efficiency, as currently deployed by cities and states in the United States.

National Research Council. (2012).
Water Reuse: Potential for Expanding the Nation's Water Supply through Reuse of Municipal Wastewater. **Washington, D.C.: The National Academies Press.**
Retrieved from: http://nas-sites.org/waterreuse/

This comprehensive study by The National Research Council assesses the potential for reclamation and reuse of municipal wastewater to expand and enhance water supply alternatives in the United States. The report reviews the suitability of water—quality and quality—of processed wastewater and considers a range of reuse applications, including drinking water, non-potable urban uses, irrigation, industrial process water, groundwater recharge and ecological enhancement. Moreover the report assesses the current state of technology in wastewater treatment and production of reclaimed water, and compares the performance, cost, energy use and environmental performance of a portfolio of treatment options and discusses risk exposure to microbial and chemical contaminants from drinking reclaimed water. In emphasizing the need for quality assurance, the study recognizes the significance of developing new monitoring and attenuation technologies. Using U.S. and international case studies, the report identifies technical, economic, institutional and social issues associated with the increased adoption of water reuse, and the available legislative tools to address the same. Finally the report considers current barriers to implementation and proposes areas for research to advance the safe, reliable and cost-effective reuse of municipal wastewater. This document is a timely and valuable guide for India and other countries, which will need to assess and address these issues with the increasing reuse of municipal wastewater.

New Mexico Office of the State Engineer. (1999).
A Water Conservation Guide for Commercial, Institutional and Industrial Users. **New Mexico. Retrieved from:**
http://www.ose.state.nm.us/water-info/conservation/pdf-manuals/cii-users-guide.pdf

This manual, produced by the New Mexico Office of the State Engineer, provides step-by-step guidance on how to design and establish a water conservation plan, including water conservation guidelines for specific uses: domestic, landscaping, cooling and heating, and industry. The manual recommends that a water conservation plan be part of an integrated approach, address technical and human elements, be based upon accurate data, and follow a logical sequence of events. The water audit must assess not just how much water is being used, but also how and by whom, and that water quality is matched to the reuse application. The plan must consider true cost of water and use life-cycle costing to evaluate water conservation options. This manual is a useful resource for water utility engineers and water systems operators at commercial, institutional and industrial facilities.

State of California. (2009).
Regulations related to recycled water updated from Titles 22 and 17 California Code of Regulations. **California, Department of Public Health.**
Retrieved from:
http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Lawbook/RWregulations-01-2009.pdf

The California Department of Public Health produced this publication as an aid to its staff regarding Titles 17 and 22 published codes. Requirements under Title 17, Division 1, Chapter 5, address the protection of drinking water supplies from contamination. The regulation assigns responsibility to the water supplier to implement a cross-connection control program, and includes detailed criteria for approval, construction, location, type, testing and maintenance of backflow preventers. (A cross-connection is a connection between a potable water system and an unapproved water system). Requirements under Title 22, Division 4, Chapters 1, 2 and 3 requirements, focus upon environmental protection and present water recycling criteria. These criteria address only recycled water from sources that contain domestic waste and specify required levels of treatment by the intended use of the recycled water (irrigation, impoundments, cooling, other), as well as, specific conditions for the area of recycled water use. The criteria also address: design and operation requirements for dual plumbed recycled water systems; use of reclaimed water for groundwater recharge; and, design, reliability, and operations and maintenance requirements for water reclamation plants. These California codes address the concerns of public health and environmental protection pertaining to the use of recycled water and are a source of reference for policy makers and those responsible for designing standards and regulations in India and elsewhere.

U.S. Environmental Protection Agency (EPA). (2012).
Guidelines *for Water Reuse.* 600/R-12/618. Washington, D.C., United States. U.S. Environmental Protection Agency and U.S. Agency for International Development.
Retrieved from: http://www.waterreuseguidelines.org/

The Guidelines for Water Reuse debuted in 1980, and were updated in 1992 and 2004. This national guidance, produced as a collaborative effort between the EPA and USAID, updates and builds upon the *2004 Guidelines for Water Reuse* with the purpose of facilitating the further development of water reclamation and reuse practices. In the U.S. water reuse is regulated by states. This document inventories state water reuse regulations and discusses regional variations of water reuse practices in the U.S. Using illustrations from U.S. and international experiences, the document discusses: steps that should be considered for water reuse in the planning and management of an integrated water resources plan; types of reuse applications; advances in wastewater treatment technologies relevant to water reuse; funding decisions related to the development and operations of sustainable water system; and, best practices for involving communities in planning projects. The document discusses a portfolio of wastewater treatment options and recognizes that the cost of wastewater treatment can be balanced with the desired level of water quality for the purpose of reuse. Moreover, the document includes over a hundred U.S. and international case studies of water reuse for various applications, as well as an inventory of recent water reuse research projects and reports. Given the context of urbanization and associated population increases and land use changes and the dynamics of changes in local climate patterns, this document will serve as an authoritative reference for India and other countries on water reclamation and reuse practices.

World Health Organization (WHO). (2006).
WHO guidelines for the safe use of wastewater, excreta and greywater, Volume 1: Policy and regulatory aspects **(3rd ed.). Geneva, World Health Organization.**
Retrieved from: http://whqlibdoc.who.int/publications/2006/9241546824_eng.pdf

This four-set volume of WHO guidelines is recognized by UN-Water—the coordinating body of UN agencies and programs working on water issues—as representing the position of the United Nations system on the issues of wastewater, excreta and graywater use and health. Volume 1 gives policy makers an overview of the benefits and risks of such use and provides guidance on the development of a conducive policy environment, regulations and institutional arrangements. The guidelines recommend that policy to addresses primary health concerns related to such use may be designed around the subject of food security or environmental protection. The widespread—formal and informal—use of wastewater, excreta and graywater in agriculture and aquaculture can contribute to nutrient and water recycling; however international policy implications on trade of safe food products and any implication of negative health impact need to be addressed.

These guidelines are based on a risk analysis approach similar to the methodology underlying the development of food safety standards that provide adequate health protection and facilitate trade in food. The guidelines recommend that the planning and development of projects include a health impact assessment or an environmental impact assessment with a health component. And that public health policy for interventions ensures the most cost effective measures or combination thereof. The guidance outlines a step-by-step process for policy formulation and adjustment and introduces the concept of intersectoral collaboration, including mechanisms to promote collaboration and integration at the national and local levels to achieve effective institutional arrangements across sectors. The guidance for developing regulations to ensure safe use identifies and discusses the following essential functions: identification of associated primary health hazards; generating evidence for health risks and the effectiveness of protection measures to manage them; establishing health-based targets to manage health risks, implementing health protection measures to achieve the targets; and monitoring and system assessments.

This document also includes a brief synthesis Volumes 2, 3 and 4 of this set, which focus upon technical information on health risk assessment, protection measures, and monitoring and evaluation. As water scarcity increasingly drives interest in the wastewater, excreta and graywater use in agriculture and aquaculture, this document offers useful guidance for policy makers on the design of policy, regulation and institutional arrangements.

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Domestic Water Conservation Technologies (undated), available at www1.eere.energy.gov/femp/pdfs/22799.pdf.

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